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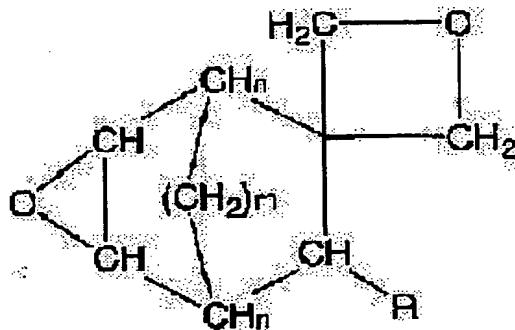
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(54) COMPOSITION FOR OPTICAL WAVEGUIDE RESIN

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a composition for an optical waveguide resin having high activity (fast polymerizing property and fast curing property) by irradiation of active energy rays and/or heating and easily controllable of the refractive index.

SOLUTION: The composition for an optical waveguide resin contains (a) an alicyclic compound having at least one oxetanyl group in the molecule and (b) compound initiating cation polymerization by irradiation of active energy rays and/or heating.



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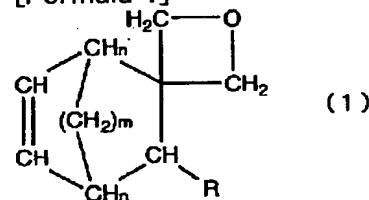
CLAIMS

[Claim(s)]

[Claim 1] The constituent for optical waveguide resin characterized by including the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular.

[Claim 2] The constituent for optical waveguide resin according to claim 1 with which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (1).

[Formula 1]

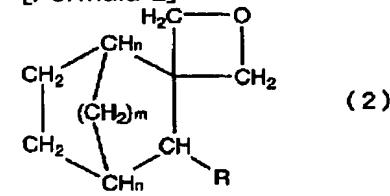


((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1-12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0-2, and the inside R of a formula is 1 except it.)

[Claim 3] The constituent for optical waveguide resin according to claim 2 characterized by the compound shown by the general formula (1) being a 2-oxaspiro [3.5] nona-6-en or a 5-methyl-2-oxaspiro [3.5] nona-6-en.

[Claim 4] The constituent for optical waveguide resin according to claim 1 with which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (2).

[Formula 2]

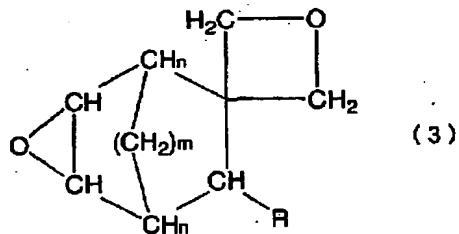


((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1-12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0-2, and the inside R of a formula is 1 except it.)

[Claim 5] The constituent for optical waveguide resin according to claim 4 characterized by the compound shown by the general formula (2) being 2-oxaspiro [3.5] nonane or a 5-methyl-2-oxaspiro [3.5] nonane.

[Claim 6] The constituent for optical waveguide resin according to claim 1 with which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (3).

[Formula 3]



((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1–12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0–2, and the inside R of a formula is 1 except it.)

[Claim 7] The constituent for optical waveguide resin according to claim 6 characterized by the compound shown by the general formula (3) being a 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane, 6, and 7-epoxy-2-oxaspiro [3.5] nonane.

[Claim 8] The constituent for optical waveguide resin according to claim 1 with which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by the thing which was chosen from the compound expressed with a general formula (1), a general formula (2), and a general formula (3), and which is a kind at least.

[Claim 9] The constituent for optical waveguide resin of any one publication of claim 1–8 characterized by containing the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical.

[Claim 10] The constituent for optical waveguide resin according to claim 9 characterized by the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical having a fluorine atom.

[Claim 11] The constituent for optical waveguide resin of any one publication of claim 1–10 characterized by including the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line.

[Claim 12] The constituent for optical waveguide resin according to claim 11 which is one or more sorts as which the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line was chosen from sulfonium salt, iodonium salt, phosphonium salt, and diazonium salt.

[Claim 13] The constituent for optical waveguide resin of any one publication of claim 1–12 characterized by including a radical polymerization nature compound (d).

[Claim 14] The constituent for optical waveguide resin of any one publication of claim 1–13 characterized by including an optical radical initiator (e).

[Claim 15] The constituent for optical waveguide resin of any one publication of claim 1–14 with which the refractive index to the D line of the sodium in 25 degrees C of a hardened material is characterized by being a value within the limits of 1.70 or less [1.40 or more].

[Claim 16] Optical waveguide which was made to harden the constituent for optical waveguide resin of any one publication of claim 1–15, and was obtained.

[Claim 17] Optical waveguide characterized by for either [at least] the core section or the clad section hardening the constituent for optical waveguide resin of any one publication of claim 1–15, and obtaining it while having the core section and the clad section.

[Claim 18] The manufacture approach of the optical waveguide which forms optical waveguide by the development which is made to harden the constituent concerned alternatively and removes a part for a non-hard spot by irradiating an activity energy line alternatively at the layer using the constituent for optical waveguide resin containing the compound (c) which makes intramolecular start cationic polymerization with the exposure and/or heating of an alicyclic compound (a) and an activity energy line which have the OKISETANIRU radical of a piece at least.

[Claim 19] The optical device with which optical waveguide according to claim 16 was used.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]**[0001]**

[Field of the Invention] This invention relates to the optical relation ingredient which used the optical waveguide for the hardenability constituent for forming the optical waveguide to which a lightwave signal can spread the interior and the optical waveguide which hardened the constituent and was obtained, and a list.

[0002]

[Description of the Prior Art] By advance of the technique in IC (Integrated circuit; integrated circuit) or LSI (Large Scale Integration; large-scale integrated circuit), those working speeds and accumulation scales improve and high-performance-izing of a microprocessor and large capacity-ization of a memory chip are attained quickly. between the chips between the boards in the former and a device, or in a board etc. — signal transduction between short distance has mainly been comparatively performed by the electrical signal. In order to raise the engine performance of an integrated circuit further from now on, the further improvement in the speed of a signal and the densification of signal wiring are needed, but in electrical signal wiring, while these improvement in the speed and densification are reaching a limitation, the signal delay by CR (C: electrostatic-capacity [of wiring], resistance of R:wiring) time constant of wiring poses a problem. Moreover, since improvement in the speed of an electrical signal and the densification of electrical signal wiring cause an EMI (Electromagnetic Interference) noise, they become indispensable [the cure].

[0003] Then, optical wiring (optical interconnection) attracts attention as what solves these problems. Optical wiring is considered [that it is applicable to various parts, such as between the chips between the boards between devices and in a device, or in a board, and]. Especially, optical waveguide is formed on the substrate in which the chip is carried, and it is considered suitable by transmission of the signal between short distance like [during a chip] to build the optical transmission and communication system which made this the transmission line.

[0004] The waveguide used here can be used for optical devices used for the optic field in addition to optical wiring, such as optical passive components, optical circuit components, etc., such as an optical switch, a fiber optic connector, an optical spectral separation multiplexing machine, an optical spectral separation coupler, an optical attenuator, and an optical isolator. About these light device, publication and p.161-175 will have a publication in "newest commercial scene of transparent plastic" CMC publication 1999. Hereafter, all the things about the waveguide used for an optical relation ingredient are summarized as optical waveguide, and are indicated.

[0005] Conventionally, inorganic glass, such as a quartz, was used as this kind of optical waveguide. However, since it was necessary to perform heat treatment by the elevated temperature to form optical waveguide using inorganic glass, heat-treating under the elevated temperature of a semi-conductor substrate, a plastic plate, etc. was not able to form optical waveguide on the difficult substrate.

[0006] On the other hand, optical waveguide using polymeric materials is being proposed and put in practical use in recent years. Polymeric materials are easy to process it as compared with an

inorganic material, and can perform large-area-izing and film-ization easily. Moreover, since it is flexible, it has various advantages, like that an application is large and adjustment of a refractive index is easy. Especially, since it is the ingredient which can be mass-produced, the resin of an ultraviolet curing mold is expected as an ingredient for optical waveguides. As resin of such an ultraviolet curing mold, the epoxy resin is known widely.

[0007] The optical waveguide using an epoxy resin is formed by performing the development which carries out wet etching of the part for the non-hard spot of resin, after applying resin on a support base and carrying out selection exposure of the resin generally.

[0008] However, since the polymerization nature of an epoxy resin was low, when optical waveguide was formed using an epoxy resin, it had the problem that a lot of energy is required in case resin is stiffened, and productive efficiency will worsen.

[0009] On the other hand, it is known by mixing an oxetane compound with an epoxy compound that cation hardening will improve remarkably. Since it is such, although the constituent for optical waveguide resin which used these oxetane compound is shown, in order to actually use for optical waveguide, in JP,2000-356720,A, the present condition is being unable to say that it has sufficient cure rate.

[0010]

[Problem(s) to be Solved by the Invention] This invention is made in view of this trouble, and it is in offering the optical waveguide which used it for the constituent for optical waveguide resin excellent in polymerization nature, and the list, and its manufacture approach.

[0011]

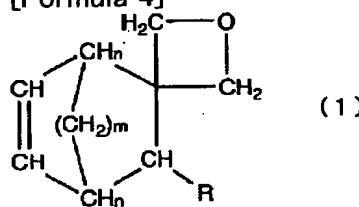
[Means for Solving the Problem] this invention persons came to complete a header and this invention for the ability of the constituent for optical waveguide resin containing a specific cationic polymerization nature compound and the compound which makes cationic polymerization start with an exposure and/or heating of an activity energy line to solve said technical problem, as a result of considering solution of the above-mentioned technical problem wholeheartedly.

[0012] That is, this invention relates to the optical waveguide which used it for the constituent for optical waveguide resin shown in the following [1] - [19], and the list, and its manufacture approach.

[0013] [1] The constituent for optical waveguide resin characterized by including the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular.

[0014] [2] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (1).

[Formula 4]

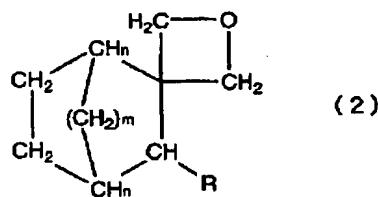


((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1-12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0-2, and the inside R of a formula is 1 except it.)

[3] The constituent for optical waveguide resin given in [2] characterized by the compound shown by the general formula (1) being a 2-oxaspiro[3.5]nona-6-en or a 5-methyl-2-oxaspiro[3.5]nona-6-en.

[0015] [4] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (2).

[Formula 5]

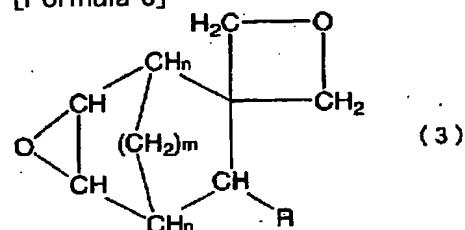


((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1–12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0–2, and the inside R of a formula is 1 except it.)

[5] The constituent for optical waveguide resin given in [4] characterized by the compound shown by the general formula (2) being 2-oxaspiro [3.5] nonane or a 5-methyl-2-oxaspiro [3.5] nonane.

[0016] [6] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (3).

[Formula 6]



((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1–12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0–2, and the inside R of a formula is 1 except it.)

[0017] [7] The constituent for optical waveguide resin given in [6] to which the compound shown by the general formula (3) is characterized by being a 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane, 6, and 7-epoxy-2-oxaspiro [3.5] nonane.

[8] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by the thing which was chosen from the compound expressed with a general formula (1), a general formula (2), and a general formula (3), and which is a kind at least.

[9] The constituent for optical waveguide resin of any one publication of [1] – [8] characterized by containing the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical.

[0018] [10] The constituent for optical waveguide resin given in [9] characterized by the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical having a fluorine atom.

[11] The constituent for optical waveguide resin of any one publication of [1] – [10] characterized by including the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line.

[12] The constituent for optical waveguide resin given in [11] which is one or more sorts as which the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line was chosen from sulfonium salt, iodonium salt, phosphonium salt, and diazonium salt.

[0019] [13] The constituent for optical waveguide resin of any one publication of [1] – [12] characterized by including a radical polymerization nature compound (d).

[14] The constituent for optical waveguide resin of any one publication of [1] – [13] characterized by including an optical radical initiator (e).

[15] The constituent for optical waveguide resin of any one publication of claim 1–14 with which the refractive index to the D line of the sodium in 25 degrees C of a hardened material is characterized by being a value within the limits of 1.70 or less [1.40 or more].

[0020] [16] [1] Optical waveguide which was made to harden the constituent for optical waveguide resin of any one publication of — [15], and was obtained.

[17] Optical waveguide characterized by for either [at least] the core section or the clad section hardening the constituent for optical waveguide resin of any one publication of [1] — [15], and obtaining it while having the core section and the clad section.

[0021] [18] The manufacture approach of the optical waveguide which forms optical waveguide by the development which is made to harden the constituent concerned alternatively and removes a part for a non-hard spot by irradiating an activity energy line alternatively at the layer using the constituent for optical waveguide resin containing the compound (c) which makes intramolecular start cationic polymerization with the exposure and/or heating of an alicyclic compound (a) and an activity energy line which have the OKISETANIRU radical of a piece at least.

[19] The optical device with which the optical waveguide of a publication was used for [16].

[0022]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail.

[0023] the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in the same intramolecular of this invention — (— it abbreviates to a compound (a) henceforth. The alicyclic compound expressed with a general formula (1), a general formula (2), or a general formula (3) as) is desirable. a general formula (1), (2), and (3) — setting — R — each of each type — it is each radical of the alkyl group of a hydrogen atom, the shape of a straight chain of carbon numbers 1–12, and the letter of branching, an aryl group, an aralkyl radical, and an alkyl halide radical independently. In these, a hydrogen atom and the alkyl group of a straight chain are desirable, and a hydrogen atom and especially a methyl group are desirable. n is 2 when m is 0, and m is the integer of 0–2 and it is 1 except it. It means that a bridging with a methylene chain does not exist in m= 0.

[0024] As the alkyl group of the shape of a straight chain of carbon numbers 1–12, and the letter of branching, an aryl group, and an aralkyl radical, a methyl group, an ethyl group, an isopropyl group, a phenyl group, benzyl, etc. are mentioned.

[0025] As an alkyl halide radical, a fluoro alkyl group, a chloro alkyl group, a BUROMO alkyl group, etc. are mentioned. Each [these] alkyl group is the shape of a straight chain, and a letter of branching, and the number of each halogen atoms should just be one or more.

[0026] As a compound expressed with a general formula (1), a 2-oxaspiro [3.5] nona-6-en, A 9-methyl-2-oxaspiro [3.5] nona-6-en, 2 - OKISA-9-phenyl SUPIRO [3.5] nona-6-en, a 9-trifluoromethyl-2-oxaspiro [3.5] nona-6-en and spiro — [the bicyclo [2.2.1] hepta—5-en -2, 3'-oxetane], and spiro — [the 3-methyl bicyclo [2.2.1] hepta—5-en -2, 3'-oxetane], etc. are mentioned. In these, a 2-oxaspiro [3.5] nona-6-en and a 9-methyl-2-oxaspiro [3.5] nona-6-en are desirable.

[0027] These compounds have the OKISETANIRU radical and the carbon carbon double bond, were excellent not only in cationic polymerization nature but radical polymerization nature, and are contributed to improvement in a cure rate. Moreover, since it has alicycle structure, the hardened material of the constituent of this invention is excellent also in thermal resistance. Furthermore, since many of compounds shown by the general formula (1) are liquids in ordinary temperature, it becomes possible [lowering the viscosity of the constituent of this invention], and may raise coating nature.

[0028] As a compound expressed with a general formula (2), 2-oxaspiro [3.5] nonane, A 7-methyl-2-oxaspiro [3.5] nonane, a 5-methyl-2-oxaspiro [3.5] nonane, A 2-OKISA-5-phenyl SUPIRO [3.5] nonane, a 5-trifluoromethyl-2-oxaspiro [3.5] nonane, spiro — [adamantane -2, 3'-oxetane], and spiro — [the bicyclo [2.2.1] heptane -2 and 3'-oxetane] — spiro — [— bicyclo one — [— 2.2.2 —] — an octane - two — three — ' - oxetane —] — spiro — [— seven - OKISA — bicyclo one — [— 2.2.1 —] — a heptane - two — three — ' - oxetane —] — spiro — [— three - methyl — bicyclo one — [— 2.2.1 —] — a heptane - two — three — ' - oxetane —] — etc. — mentioning — having . In these, 2-oxaspiro [3.5] nonane and a 5-methyl-2-oxaspiro [3.5] nonane are desirable.

[0029] These compounds are excellent in cationic polymerization nature, and have the effectiveness of the improvement in a cure rate of a constituent. Moreover, the alicycle structure gives thermal resistance to the hardened material of the constituent of this invention. Furthermore, since many of compounds shown by the general formula (2) are liquids in ordinary temperature, it becomes possible [lowering the viscosity of the constituent of this invention], and may raise coating nature.

[0030] As a compound expressed with a general formula (3), 7, a 8-epoxy-5-methyl-oxaspiro [3.5] nonane, 7, a 8-epoxy-5-ethyl-2-oxaspiro [3.5] nonane, 7, a 8-epoxy-2-OKISA-5-phenyl SUPIRO [3.5] nonane, 7, 8 oxaspiro [- epoxy-5-truffe RIORO methyl-2-] [3.5] nonane, six — seven — epoxy — two — oxaspiro — [— 3.5 —] — a nonane — spiro — [— five — six — epoxy — norbornane — two — three — ' — oxetane —] — spiro — [— five — six — epoxy — three — methyl — norbornane — two — three — ' — oxetane —] — etc. — it is . In these, a 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane, 6, and 7-epoxy-2-oxaspiro [3.5] nonane is desirable.

[0031] These compounds had the OKISETANIRU radical and the epoxy group simultaneously, were excellent in cationic polymerization nature, and are contributed to improvement in the cure rate of a constituent. Moreover, it has alicycle structure and the thermal resistance of a hardened material is raised.

[0032] Compounds (a) including the alicyclic compound which has an OKISETANIRU radical more than a piece in the intramolecular expressed with a general formula (1), (2), and (3) are independent, or can be used as two or more sorts of mixture. the loadings (when using two or more sorts together, they are those total quantities) of these compounds (a) — the inside of the constituent for optical waveguide resin of this invention — desirable — 1 — 90 mass % — it is 10 — 60 mass % still more preferably.

[0033] As a compound (b) which has an epoxy group more than a piece in the intramolecular of this invention, and does not have an OKISETANIRU radical, the epoxy compound of well-known common use can be used. This epoxy compound will not be limited, especially if it has an epoxy group more than a piece in 1 molecule and does not have an OKISETANIRU radical.

[0034] Specifically Bisphenol A diglycidyl ether, bisphenol F diglycidyl ether, Bisphenol S diglycidyl ether, bromination bisphenol A diglycidyl ether, Bromination bisphenol F diglycidyl ether, bromination bisphenol S diglycidyl ether, a novolak mold epoxy resin (for example, a phenol novolak mold epoxy resin —) A cresol novolak mold epoxy resin, a bromination phenol novolak mold epoxy resin, Hydrogenation bisphenol A diglycidyl ether, hydrogenation bisphenol F diglycidyl ether, hydrogenation bisphenol S diglycidyl ether, triglycidyl isocyanurate, etc. can be used.

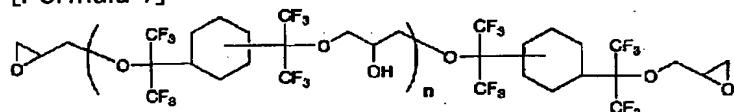
[0035] Moreover, it is methyl (3, 4-epoxycyclohexyl) as an aliphatic series epoxy compound. — 3', 4'-epoxycyclohexyl carboxylate, 2-(3, 4-epoxycyclohexyl —5, 5-spiro —3, 4-epoxy) cyclohexane—meta—dioxane, A bis(3, 4-epoxycyclohexyl methyl) horse mackerel peat, vinyl cyclohexene oxide, 4-vinyl epoxy cyclohexane, a bis(3, 4-epoxy-6-methylcyclohexyl methyl) horse mackerel peat, 3, 4-epoxy-6-methylcyclohexyl — 3', 4 '— epoxy —6'—methylcyclohexane carboxylate, Methylenebis (3, 4-epoxy cyclohexane), dicyclopentadiene diepoxide, Limonene diepoxide, the JI (3, 4-epoxycyclohexyl methyl) ether of ethylene glycol, and an ethylene screw (3, 4-epoxy cyclohexane carboxylate) are mentioned.

[0036] Furthermore, epoxy hexahydrophthalic acid dioctyl, epoxy hexahydrophthalic acid G 2—ethylhexyl, 1,4-butanediol diglycidyl ether, 1, 6-hexanediol diglycidyl ether, Glycerol triglycidyl ether, trimethylolpropane triglycidyl ether, Polyethylene glycol diglycidyl ether, polypropylene glycol diglycidyl ether, Ethylene glycol, propylene glycol, By adding one sort or two sorts or more of alkylene oxide to aliphatic series polyhydric alcohol, such as a glycerol The monoglycidyl ether of the diglycidyl ether; aliphatic series higher alcohol of the Pori glycidylethers; aliphatic series long-chain dibasic acid of the polyether polyol obtained; Butyl glycidyl ether, Phenyl glycidyl ether, KUREZORU glycidyl ether, nonylphenyl glycidyl ether, Glycidyl methacrylate; A phenol, cresol, Glycidyl ester; epoxidized soybean oil of a monoglycidyl ether; higher fatty acid of the polyether alcohol which adds alkylene oxide to butylphenol or these, and is obtained; Epoxy butyl stearate, Epoxy stearin acid octyl, the epoxidation linseed oil, epoxidation polybutadiene, etc. can be mentioned.

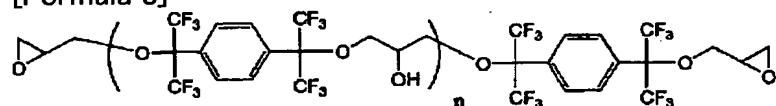
[0037] In order to adjust the refractive index of the optical waveguide of this invention furthermore, the fluorination epoxy compound which has a fluorine atom can be used. A fluorination epoxy compound can be adjusted to a desired refractive index by having a small refractive index as compared with the hydrocarbon mold epoxy compound which has the same structure, and mixing to the resin constituent for optical waveguides.

[0038] Although the example of the following compound is specifically indicated by "volume [of application physics / 68th] No. 1 (1999), and p.4-13", this invention is not limited to these.

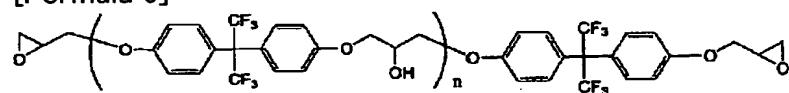
[Formula 7]



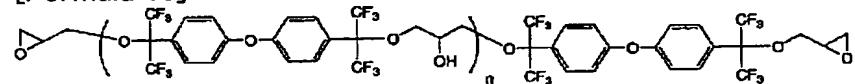
[Formula 8]



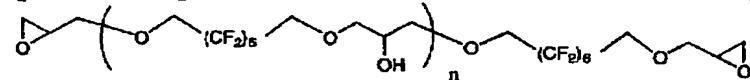
[Formula 9]



[Formula 10]



[Formula 11]



[0039] The compound (b) which has an epoxy group more than a piece in these intramoleculars, and does not have an OKISETANIRU radical is independent, or two or more sorts can use it, mixing.

[0040] The sum total of a compound [in / in the loadings (when using two or more sorts together, they are those total quantities) of a compound (b) / this invention] (a): The 1 – 10,000 mass section is desirable to the 100 mass sections, and especially the 10 – 1,000 mass section is desirable.

[0041] The compound (c) which makes cationic polymerization start with the exposure and/or heating of an activity energy line as used in the field of this invention can change with the exposures of activity energy lines, such as heating and ultraviolet rays, and can be used as the compound which generates the matter which makes cationic polymerization, such as an acid, start. Therefore, a compound (c) is a kind of cationic initiator, and is also called the "acid generator" in this industry. Henceforth, in this invention, a compound (c) is also called an acid type-of-seasonal-prevalence cationic initiator.

[0042] By the optical exposure of heating or ultraviolet rays, an acid type-of-seasonal-prevalence cationic initiator promotes the cationic polymerization of the compound (a) of this invention, a compound (b), and other cationic polymerization nature matter (compound containing an OKISETANIRU radical etc.), and advances smoothly hardening of the constituent for optical waveguide resin of this invention.

[0043] Moreover, the acid type-of-seasonal-prevalence cationic initiator as used in the field of this invention changes with the exposures of activity energy lines, such as heating and ultraviolet rays, it is the compound which generates the matter which makes cationic polymerization, such

as an acid, start, and the compound which has taken the form of an acid from the beginning like a carboxylic acid is not contained.

[0044] Sulfonium salt well-known as an acid type-of-seasonal-prevalence cationic initiator, iodonium salt, phosphonium salt, diazonium salt, ammonium salt, and ferrocenes are mentioned. Although illustrated concretely below, it is not limited to these compounds.

[0045] As an acid type-of-seasonal-prevalence cationic initiator of a sulfonium salt system Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Screw hexafluorophosphate, Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Screw hexafluoroantimonate, Screw [4-(diphenyl SURUHONIO) phenyl] sulfide screw tetrafluoroborate, Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Tetrakis(pentafluorophenyl) borate, Diphenyl-4-(phenylthio) phenyl sulfonium Hexafluorophosphate, Diphenyl-4-(phenylthio) phenyl sulfonium Hexafluoroantimonate, Diphenyl-4-(phenylthio) phenyl sulfonium tetrafluoroborate, Diphenyl-4-(phenylthio) phenyl sulfonium Tetrakis(pentafluorophenyl) borate, Triphenylsulfonium hexafluorophosphate, triphenylsulfonium hexafluoroantimonate, Triphenylsulfonium tetrafluoroborate, triphenylsulfonium tetrakis(pentafluorophenyl) borate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw hexafluorophosphate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw hexafluoroantimonate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw tetrafluoroborate, Screw [4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide tetrakis(pentafluorophenyl) borate etc. is mentioned.

[0046] As an acid type-of-seasonal-prevalence cationic initiator of an iodonium salt system Diphenyliodonium Hexafluorophosphate, diphenyliodonium Hexafluoroantimonate, Diphenyliodonium Tetrafluoroborate, diphenyliodonium Tetrakis(pentafluorophenyl) borate, Bis(dodecyl phenyl) iodonium Hexafluorophosphate, Bis(dodecyl phenyl) iodonium Hexafluoroantimonate, Bis(dodecyl phenyl) iodonium Tetrafluoroborate, Bis(dodecyl phenyl) iodonium Tetrakis(pentafluorophenyl) borate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Hexafluorophosphate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Hexafluoroantimonate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Tetrakis(pentafluorophenyl) borate etc. is mentioned.

[0047] As an acid type-of-seasonal-prevalence cationic initiator of a phosphonium salt system, ethyltriphenylphosphonium tetrafluoroborate, ethyltriphenylphosphonium hexafluorophosphate, ethyltriphenylphosphonium hexafluoroantimonate, tetrabutyl phosphonium tetrafluoroborate, tetrabutyl phosphonium hexafluorophosphate, tetrabutyl phosphonium hexafluoroantimonate, etc. are mentioned.

[0048] As an acid type-of-seasonal-prevalence cationic initiator of a diazonium salt system, it is phenyl diazonium. Hexafluorophosphate, phenyl diazonium Hexafluoroantimonate, phenyl diazonium Tetrafluoroborate, phenyl diazonium Tetrakis(pentafluorophenyl) borate etc. is mentioned.

[0049] As an acid type-of-seasonal-prevalence cationic initiator of an ammonium salt system 1-benzyl-2-cyano pyridinium Hexafluorophosphate, 1-benzyl-2-cyano pyridinium Hexafluoroantimonate, 1-benzyl-2-cyano pyridinium Tetrafluoroborate, 1-benzyl-2-cyano pyridinium tetrakis(pentafluorophenyl) borate, 1-(naphthyl methyl)-2-cyano pyridinium Hexafluorophosphate, 1-(naphthyl methyl)-2-cyano pyridinium Hexafluoroantimonate, 1-(naphthyl methyl)-2-cyano pyridinium Tetrafluoroborate, 1-(naphthyl methyl)-2-cyano pyridinium Tetrakis(pentafluorophenyl) borate etc. is mentioned.

[0050] As an acid type-of-seasonal-prevalence cationic initiator of a ferrocene system [(1-methylethyl) benzene]-Fe(II) hexafluorophosphate, (2, 4-cyclopentadiene-1-IRU) [(1-methylethyl) benzene]-Fe(II) hexafluoroantimonate, (2, 4-cyclopentadiene-1-IRU) 2, 4-cyclopentadiene-1-IRU [(1-methylethyl) benzene]-Fe(II) tetrafluoroborate, 2, 4-cyclopentadiene-1-IRU [(1-methylethyl) benzene]-Fe(II) tetrakis(pentafluorophenyl) borate, etc. are mentioned.

[0051] In these acid type-of-seasonal-prevalence cationic initiators, the initiator of sulfonium salt and an iodonium salt system is desirable from the field of a cure rate, stability, and economical efficiency. As a commercial item SAN-AID SI[by the CI-2639; 3 Japanese Federation of Chemical Industry Workers' Unions industrial company]-60; SP[by Asahi Denka

Kogyo K.K.] - 150, SP-170, CP-66, CP-77; Union Carbide CYRACURE-UVI-6990, and UVI-6974; Nippon Soda Co., Ltd. make — CI-2855 — "The IRUGA cure 261" (Ciba Specialty Chemicals [(1-methylethyl) benzene] (2, 4-cyclopentadiene-1-IRU)-Fe (II) hexafluorophosphate), "Load sill (RHODORSIL) 2074"; (Rhone-Poulenc shrine 4-methylphenyl-4-(1-methylethyl) phenyliodonium tetrakis (pentafluorophenyl) borate) etc. is mentioned.

[0052] These acids type-of-seasonal-prevalence cationic initiator can be chosen from the ingredients mentioned above, can also be used independently, and can also be used combining two or more kinds. although especially the range where the amount of the acid type-of-seasonal-prevalence cationic initiator used is suitable does not have a limit — the loadings (total quantity which united them when compound in which other below-mentioned cationic polymerization is possible was used together) 100 mass section of the sum total of a compound (a) and a compound (b) — receiving — 0.05 – 25 mass section — it is 1 – 20 mass section preferably. If there are few additions than the 0.05 mass section, in order to become a defect of sense and to fully harden, high temperature processing of remarkable optical big exposure energy or long duration is required. Moreover, even if it adds exceeding 25 mass sections, improvement in sensibility is not carried out and is not economically desirable. Conversely, there is a possibility that the amount which remains as a non-hardened component may increase and the physical properties of a hardened material may fall into a constituent.

[0053] The cationic polymerization nature monomer shown below in this invention can also be added to the constituent for optical waveguide resin of this invention in the range which does not affect hardenability and hardened material physical properties. This cationic polymerization nature monomer is classified into the compound which is a compound which causes a polymerization initiation reaction and crosslinking reaction with the acid which the acid type-of-seasonal-prevalence cationic initiator generated, and is except a compound (a) and a compound (b). For example, trimethylene oxide, 3, and 3-dimethyl oxetane, 3, and 3-dichloro methyl oxetane, 3-ethyl-3-phenoxyethyl oxetane, 3-ethyl-3-hydroxymethyloxetane (Toagosei make; trade name EOXA), Bis[(3-ethyl-3-OKISETA nil methoxy) methyl] benzene (alias name xylylene JIOKI cetane; Toagosei; trade name XDO), Tori [(3-ethyl-3-OKISETA nil methoxy) methyl] benzene, The bis[(3-ethyl-3-OKISETA nil methoxy) methylphenyl] ether, 3-ethyl-3-[(oxy-RANIRU methoxy) methyl] oxetane, The oxetane compound to which the OKISETANIRU radical is attached in addition to alicyclic compounds, such as oligo dimethylsiloxane; A tetrahydrofuran, (3-ethyl-3-OKISETA nil methoxy) Oxo-run compounds, such as 2 and 3-dimethyl tetrahydrofuran; A trioxane, Annular acetal compounds, such as 1, 3-dioxolane, 1 and 3, and 6-trioxane cyclooctane; Beta propiolactone, Annular lactone compounds, such as epsilon-caprolactone; An ethylene sulfide, Thiethane compounds, such as thiirane compound;3, such as 1, 2-propylene sulfide, and thio epichlorohydrin, and 3-dimethyl thiethane; The ethylene glycol divinyl ether, The SUPIRO orthochromatic ester compound which is a resultant of a vinyl ether compound; epoxy compound and lactone, such as the TORIECHIRENGURI COL divinyl ether and the trimethylol propane TORIBI nil ether; A vinyl cyclohexane, Ethylene nature unsaturated-compound; cyclic ether compound; annular thioether compounds, such as an isobutylene and polybutadiene; a vinyl compound etc. can be mentioned.

[0054] These cationic polymerization nature monomers can also add one sort independently, or can also add it combining two or more sorts. the loadings (when using two or more sorts together, they are those total quantities) of these cationic polymerization nature monomer — sum total [of the compound (a) of this invention]: — the 100 mass sections — receiving — the 1 – 10,000 mass section — it is the 10 – 1,000 mass section preferably. Since hardenability will fall and energy required for hardening will increase if the compound with which only one has a cationic polymerization nature machine is added more than the 200 mass sections to the sum total:100 mass section of a compound (a) among the above-mentioned cationic polymerization nature monomers to intramolecular, it is not desirable.

[0055] In order to raise optical (activity energy line) hardenability to the constituent for optical waveguide resin of this invention, it is the range which does not check the purpose of this invention, and it is also possible to add a radical polymerization nature compound (d). As a compound (d), although there is especially no limitation, it can use the radical polymerization

nature monomer of well-known common use of an acrylic ester (meta) system. Specifically Methyl (meta) acrylate, ethyl (meta) acrylate, n-propyl (meta) acrylate, n-butyl (meta) acrylate, 2-ethylhexyl (meta) acrylate, lauryl (meta) acrylate, Cyclohexyl (meta) acrylate, phenoxy ethyl (meta) acrylate, 2-ethoxyethyl (meta) acrylate, glycidyl (meta) acrylate, 2-hydroxyethyl (meta) acrylate, benzyl (meta) acrylate, Monofunctional (meta) acrylate compounds, such as ethylene glycol monochrome (meta) acrylate; Ethylene GURIKORUJI (meta) acrylate, Polyethylene GURIKORUJI (meta) acrylate, TORIMECHI roll pro pantry (meta) acrylate, Pentaerythritol tetrapod (meta) acrylate, dipentaerythritol PENTA (meta) acrylate, polyfunctional epoxy (meta) acrylate resin, polyfunctional urethane (meta) acrylate resin, etc. can be mentioned.

[0056] Moreover, it is the purpose which adjusts the refractive index of the optical waveguide of this invention, and it is also possible to use the acrylate monomer which has a fluorine atom (meta) as a compound (d). Specifically, 2, 2, and 2-trifluoroethyl (meta) acrylate, 2, 2 and 3, 3-tetrafluoro propyl (meta) acrylate, pentafluoro propyl (meta) acrylate, hexafluoro isopropyl (meta) acrylate, octafluoropentyl (meta) acrylate, etc. can be mentioned.

[0057] the total 100 mass section of the cationic polymerization nature compound the compound (a) of this invention, a compound (b), a compound (c), and ****s other than these — receiving — the 5 – 200 mass section — it is the 10 – 100 mass section preferably. [the addition of a compound (d)] If an addition exceeds the 200 mass sections, set-to-touch nature will worsen. Moreover, since the rate of bridge formation of an acrylic (meta) radical increases in hardening, the thermal resistance of the obtained hardened material and chemical resistance fall.

[0058] In order to promote smoothly the radical polymerization of the above-mentioned radical polymerization nature compound (d), the thing of the well-known common use which it is desirable adding an optical radical initiator (e), it induces light, and generates a radical can be used. "Light" means radiations, such as a visible ray, ultraviolet rays, far ultraviolet rays, an X-ray, and an electron ray, here. As an optical radical initiator (e), for example A benzoin, benzoin ethyl ether, Benzoin iso-propyl ether, benzoin-n-butyl ether, Benzoin isobutyl ether, an acetophenone, a dimethylamino acetophenone, A 2 and 2-dimethoxy-2-phenyl acetophenone, 2, and 2-diethoxy-2-phenyl acetophenone, 2-hydroxy – 2-methyl-1-phenyl propane-1-ON, 1-hydroxy cyclohexyl phenyl ketone, 2-methyl – 1-[4-(methylthio) phenyl]-2-morpholino propane-1-ON (the product made from tiba speciality KEMIKARUZU; IRUGA cure 907), A 4-(2-hydroxy ethoxy) phenyl-2-(hydroxy-2-propyl) ketone, A benzophenone, p-phenylbenzo phenon, 4, and 4'-diethylamino benzophenone, A dichloro benzophenone, 2-methyl anthraquinone, 2-t-butyl anthraquinone, 2-aminoanthraquinone, 2-methylthio xanthone, 2-ethyl thioxan ton, 2-chloro thioxan ton, 2, 4-diethyl thioxan ton, benzyl dimethyl ketal, p-dimethylamine benzoate, 2 and 4, 6-trimethyl benzoyl diphenyl phosphine oxide (BASF A.G. make; RUSHIRIN TPO), Screw (2, 6-dimethoxybenzoyl) – 2, 4, and 4-TORIMECHIRU-pentyl phosphine oxide content initiator (the product made from tiba speciality KEMIKARUZU; IRUGA cures 1700, 149, and 1800), Bis(2, 4, 6-trimethyl benzoyl)-phenyl phosphine oxide (the product made from tiba speciality KEMIKARUZU; IRUGA cure 819) etc. is mentioned. These can be used as one sort or two sorts or more of mixture.

[0059] 0.007–0.5 mols can be used for the amount of the optical radical initiator (e) used to 1Eq of radical polymerization nature functional groups, such as an acrylic (meta) radical of the radical polymerization nature compound in a constituent (d).

[0060] An ion trap agent can be included in the constituent for optical waveguide resin of this invention if needed. An ion trap agent can be changed to the matter which reacts with the impurity which consists of an anion or a cation, and is defanged.

[0061] The constituent for optical waveguide resin of this invention may contain aliphatic series polyol further. This aliphatic series polyol gives flexibility to the optical waveguide resin of this invention, or gives effectiveness, such as raising the integration of a reaction in room temperature aging after a hardening reaction. As aliphatic series polyol, a glycerol besides alkylene glycol (Pori), such as ethylene glycol, propylene glycol, a polyethylene glycol, a polypropylene glycol, and a butylene glycol, polyglycerin, pentaerythritol, the poly caprolactone polyol, etc. are mentioned, for example. the loadings — per total 100 mass section of component [in the constituent for optical waveguide resin of this invention] (a) – (e), and other cationic

polymerization nature monomer components, and 5 – 50 mass section — you may be 10 – 30 mass section extent preferably.

[0062] A sensitizer can also be used in order to raise a rate of polymerization, in case polymerization hardening of the constituent for optical waveguide resin of this invention is carried out by the ultraviolet rays which are one of the activity energy lines. As a sensitizer used for such the purpose, a pyrene, perylene, 2, 4-diethyl thioxan ton, 2, 4-dimethyl thioxan ton, 2, 4-dichloro thioxan ton, phenothiazin, etc. are mentioned. The amount of [in the case used of using a sensitizer together] has the desirable range of the 0.1 – 100 mass section to the photo-oxide type-of-seasonal-prevalence cationic initiator 100 mass section.

[0063] furthermore, the additives of well-known common use like stress relaxation agents, such as flame retarders, such as a nitrogen-containing compound, silicone oil, and silicone rubber powder, including adhesion grant agents by the Shin-etsu silicone company, such as defoaming agent; leveling agent; imidazole systems, such as a silicone system, a fluorine system, and a giant-molecule system, a thiazole system, a triazole system, and a silane coupling agent, for example, a silane coupling agent, KBM303 and KBM403, a KBM402; antimony trioxide, phosphoric ester, red phosphorus, and melamine resin can be used if needed.

[0064] The constituent for optical waveguide resin of this invention can be obtained by mixing constituents, such as a compound (a) described so far, a compound (b), and a compound (c), with the mixed equipment of well-known common use of the agitator by the wing, a stirring kneading machine, a paint shaker, a kneader, 3 roll mills, etc. Although there will be especially no limitation if mixed equipment is equipment which can mix each constituent to homogeneity, it is necessary to select in consideration of the viscosity of a constituent etc.

[0065] The polymerization (hardening) of the constituent for optical waveguide resin in this invention can be carried out with an exposure and/or heating of an activity energy line. An activity energy line here shows ultraviolet rays, an X-ray, an electron ray, a gamma ray, etc. As the light source in the case of irradiating ultraviolet rays, a metal halide lamp, a mercury arc lamp, a xenon arc lamp, a fluorescent lamp, a carbon arc lamp, a tungsten-halogen copy lamp, sunlight, etc. can be mentioned.

[0066] the case where the constituent for optical waveguide resin of this invention is stiffened with heating — heating conditions — desirable — about 50–250 degrees C — more — desirable — about 75–200 degrees C — setting — about 0.2 – 60 minutes — desirable — about 0.5— it is more preferably good as conditions for about 1 – 10 minutes for 20 minutes.

[0067] As for the refractive index of the optical waveguide of this invention, it is desirable that it is 1.40–1.70 to the D line of the sodium in 25 degrees C, and the core section or the clad section of optical waveguide is formed in this range. Therefore, it is desirable for the refractive indexes of the constituent for optical waveguide resin to be also 1.40–1.70. The core section and the clad section which constitute optical waveguide can form the optical waveguide which the refractive-index difference of the core section and the clad section excelled in the optical propagation property about by 1.5 in the case of the single mode when the refractive index was about [0.01 to 0.1 or more] in the case of about [0.001 or more] and a multimode.

[0068] Generally, the constituents for optical waveguide resin are mixture, such as an oxetane compound and an epoxy compound, as described until now. As for these oxetane compound and an epoxy compound, it is possible for a refractive index to control the refractive index of optical waveguide resin to arbitration by changing to be 1.40 to about 1.70 and to choose these compounds appropriately and a compounding ratio.

[0069] Next, an example of the manufacture approach of optical waveguide using the constituent for optical waveguide resin is explained with reference to drawing 1.

[0070] First, as shown in drawing 1 (A), on the substrate 10 which consists of silicon, it applies so that the thickness after hardening the constituent for the optical waveguide clad sections may be set to about 30 micrometers, and constituent layer 11a for the clad sections is formed.

[0071] Next, as shown in drawing 1 (B), the constituent for the optical waveguide clad sections is stiffened to constituent layer 11a for the clad sections using an extra-high pressure mercury lamp by irradiating ultraviolet rays for 60 seconds with the output of 25 mW/cm² on the whole surface. Thereby, as shown in drawing 1 (C), the clad section 11 of optical waveguide is formed.

In addition, if constituent layer 11a is stiffened completely, a refractive index will become large about 0.025, for example. When hardening the clad section, the approach by photo-curing is possible, and heat curing which used the heat cation curing agent in complete hardening is also possible.

[0072] Next, as shown in drawing 1 (D), on the clad section 11, it applies so that the thickness after hardening the constituent for the optical waveguide core sections may be set to about 30 micrometers, and constituent layer 12a is formed.

[0073] Furthermore, ultraviolet rays are irradiated to constituent layer 12a through the photo mask 21 which has stripe-like opening. Alignment is carried out, a photo mask 21 is specifically arranged so that constituent layer 12a for the core sections may not be contacted on constituent layer 12a for the core sections, and ultraviolet rays are irradiated towards constituent layer 12a from a photo-mask 21 side. The exposure of ultraviolet rays is performed for 5 – 120 seconds with the output of 20 – 200 mW/cm² using an extra-high pressure mercury lamp. Thereby, as shown in drawing 1 (E), in the part 12a1 corresponding to opening of the photo mask 21 of constituent layer 12a for the core sections, the constituent for the optical waveguide core sections hardens.

[0074] As mentioned above, it is necessary to arrange a photo mask 21, in order for constituent layer 12a for the core sections and a photo mask 21 to paste up, if ultraviolet rays are irradiated after non-hardened constituent layer 12a for the core sections and a photo mask 21 have stuck here so that constituent layer 12a for the core sections may not be contacted. There are a pro squeak tee exposing method exposed by preparing the gap of about 100 micrometers between a mask and the exposed body as such an approach, the projection exposing method which is made to estrange a mask and the exposed body and is exposed by carrying out image formation optically.

[0075] After irradiating ultraviolet rays and predetermined time amount passes, ultraviolet rays are not irradiated with a photo mask 21, but dissolution removal of the part 12a2 in the condition of not hardening is carried out with developers, such as an acetone. Since the crosslinking density of the part 12a1 which the clad section 11 and core section constituent layer 12a hardened is high at this time, there is little possibility that these fields will dissolve.

[0076] Next, hardened material layer 12a is washed using isopropyl alcohol as a rinse, and the acetone which permeates the interior of hardened material layer 12a, and is made to swell hardened material layer 12a is removed. Thereby, as shown in drawing 1 (F), a flat-surface configuration is beltlike and the core section 12 of two or more optical waveguides whose refractive indexes are about 1.56 is formed.

[0077] Finally, as shown in drawing 1 (G), using the ingredient same on the exposure of the clad section 11, and the core section 12 as the clad section 11, by the same approach as the clad section 11, the clad section 13 is formed and the optical waveguide of the embedding mold which consists of the core section 12 and the clad sections 11 and 13 is completed.

[0078] Thus, in the manufactured optical waveguide, if a lightwave signal carries out incidence to an end side, this lightwave signal will spread the interior and it will carry out outgoing radiation from an other end side.

[0079] As for the developer used in the manufacture approach of the optical waveguide in this invention, it is desirable that the effect which is excellent in the solubility over the part in the condition of not hardening, i.e., the solubility over the constituent for optical waveguide resin, and it has on the hardened part uses few solvents. As such a solvent, ethyl acetate, butyl acetate, gamma-butyrolactone, Ester, such as ethylene glycol monoethyl ether acetate and propylene-glycol-monomethyl-ether acetate; Ethylene glycol monoethyl ether, Diethylene glycol monoethyl ether, propylene glycol monomethyl ether, Ether alcohol, such as dipropylene glycol monomethyl ether; An acetone, The ether, such as ketone; dioxanes, such as a methyl ethyl ketone and methyl isobutyl ketone, and a tetrahydrofuran; aromatic hydrocarbon, such as benzene, toluene, and a xylene, etc. is mentioned. These may be used by one sort, and may mix and use two or more sorts. Moreover, the solvent with low solubility of the constituent for optical waveguide resin, for example, water, alcohol, etc., may be added to these solvents, and the bloating tendency of a hardened material may be adjusted to them. Among these solvents, since toxicity

is low and the boiling point is also low, the acetone also has the advantage of being easy to deal with it generally, and is desirable.

[0080] Since the hardened core section is hardly invaded but it is easy to dissolve it with a developer, while using isopropyl alcohol as a rinse used in the manufacture approach of the optical waveguide in this invention can remove a part for a non-hard spot completely, it is because it can finish without leaving the hardened core part in a nearly perfect form, and leaving dust to a substrate top face.

[0081] As a rinse used for such the purpose, although it changes also with classes of developer, lower alcohol, such as a methanol, ethanol, isopropyl alcohol, and a butanol, is desirable. Furthermore, it is isopropyl alcohol preferably.

[0082]

[Example] Although an example is given and this invention is hereafter explained further to a detail, this invention is not limited to these examples at all. In addition, the "section" in an example and the example of a comparison is the mass section as long as there is no notice especially.

[0083] In addition, among the ingredients used in the example and the example of a comparison, the commercial item was as follows, and it was used as it was, without refining.

POX: The Toagosei make, 3-ethyl-3-phenoxyethyl oxetane XDO : The Toagosei make, 1 and 4-bis[(3-ethyl-3-OKISETA nil methoxy) methyl] benzene 3000 : The Daicel Chemical Industries, Ltd. make (trade name SEROKI side 3000), Limonene dioxide 2110 : The Asahi Denka Kogyo make (trade name KRM-2110), 2 organic-functions cycloaliphatic epoxy resin 828 : Oil-ized shell epoxy company make (trade name Epicoat 828), Bisphenol A mold epoxy resin M-309:Toagosei make and trimethylolpropane triacrylate 3000A : Epoxy ester by Kyoeisha chemistry company 3000A, Bisphenol A diglycidyl-ether acrylic-acid addition-product SI-60L: 3 Japanese Federation of Chemical Industry Workers' Unions industrial company make (trade name SAN-AID SI-60L), a heat cationic initiator (sulfonium salt)

6990: Made in Union Carbide (trade name UVI-6990), the optical cationic initiator 907 : the Ciba Specialty Chemicals make (trade name IRUGA cure 907), a photopolymerization initiator [0084] That to which the artificer did chemosynthesis of the compound which is not marketed was used. That is, about the 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane and 6, and 7-epoxy-2-oxaspiro [3.5] nonane, this invention person compounded the approach given in a U.S. Pat. No. 3388105 number to reference. In detail, the 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane was compounded as follows.

[0085] 2-methyl-4-cyclohexene-1-carboaldehyde 327g which is the Diels-Alder resultant of a butadiene and a crotonaldehyde, methanol 600ml, and 729g of 37% of formalin water are fed into a <composition of 6-methyl-3-cyclohexene -1 and 1-dimethanol> 3 opening flask, and the temperature up was carried out to 60 degrees C, stirring this solution. Then, the solution which dissolved KOH252g in 600ml of distilled water was dropped over 2 hours. After continuing stirring for 7 hours, vacuum concentration of the reaction solution was carried out, and the residue of a bilayer was obtained. 300ml distilled water washed the oil reservoir condensed by about 150ml. After carrying out vacuum concentration of the oil reservoir, 50mg (BHT) of 3 and 5-JI (t-butyl)-4-hydroxytoluene was added, vacuum distillation was performed, and 6-methyl-3-cyclohexene -1 and 1-dimethanol 311g (82% of yield) which is a colorless crystal was obtained.

[0086] 6-methyl-3-cyclohexene -1 and 1-dimethanol 310g (1.99 mol), dimethyl carbonate (DMC) 894g, and 0.93g of potassium carbonate were taught to the <composition of 6-methyl-3-cyclohexene -1 and 1-dimethanol annular carbonate> 3 opening flask, the temperature up was carried out to 90 degrees C, and it was made to flow back for 4 hours. The reaction solution was returned to the room temperature and potassium carbonate was carried out the ** exception.

After adding 120mg of BHT(s), DMC and the methanol which remain were removed under reduced pressure of 2kPa(s) (15mmHg), vacuum distillation was performed continuously, and 326g (89.4% of yield) of the 6-methyl-3-cyclohexenes -1 and 1-dimethanol annular carbonates which are an ordinary temperature colorlessness crystal were obtained.

[0087] The 6-methyl-3-cyclohexene -1, 321.15g of 1-dimethanol annular carbonates, BHT642mg (0.2 mass %), and LiCl1.93g were taught to the <composition of 9-methyl-2-oxaspiro [3.5] nona-

6-en (CHEO) > 3 opening flask, and heating stirring was carried out at 275 degrees C using the mantle heater. Heating was continued for 4 hours until it stopped having extracted and distilled the product immediately the bottom of reduced pressure of about 8 kPa(s) (60mmHg), and out of the system. BHT600mg was added to the product, vacuum distillation was performed and 187g (71% of yield) of CHEO(s) which are a transparent and colorless liquid was obtained.

[0088] Since <composition of 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane (ECHO)> CHEO50g was dissolved in 150ml dichloromethane, it supplied to the reactor. The thing which made 400ml dichloromethane suspend 93.7g of m-chloro perbenzoic acids was dropped over 1 hour so that a reaction solution might not exceed 40 degrees C. Depositing m-chloro benzoic acid was carried out the ** exception, and was often washed by cold dichloromethane. 15.0g of calcium hydroxides was thrown into the organic layer, the depositing crystal was carried out the ** exception after 30-minute stirring, and it washed by cold dichloromethane. It condensed, after 5% of NaHSO4 water and saturation brine washed the organic layer, and 38.1g (73.7% of yield) of ECHO(s) of a colorless semisolid configuration was obtained in ordinary temperature by vacuum distillation.

[0089] The 6-ethyl-3-cyclohexene-1-carboaldehyde which is the Diels-Alder resultant of a butadiene and trans-2-pen TENARU was used instead of the Diels-Alder resultant of the butadiene and crotonaldehyde which were used by composition of the <composition of a 7 and 8-epoxy-5-ethyl-2-oxaspiro [3.5] nonane (EECHO)> ECHO, and this invention person compounded with the procedure similar to the above.

[0090] instead of [of the Diels-Alder resultant of the butadiene and crotonaldehyde which were used by composition of the <composition of a 7 and 8-epoxy-5-trifluoromethyl-2-oxaspiro [3.5] nonane (EFCHO)> ECHO] — a butadiene and trans- the Diels-Alder resultant with a 4, 4, and 4-trifluoro-2-buthenal was used, and this invention person compounded with the procedure similar to the above.

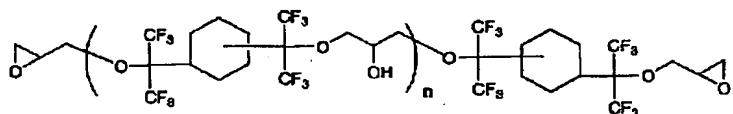
[0091] 5% palladium / activated carbon is made into a catalyst for the aforementioned 6-methyl-3-cyclohexene-1 and 1-dimethanol in toluene at a <composition of 5-methyl-2-oxaspiro [3.5] nonane (CHO)> 1L3 opening flask. 2-methylcyclohexane [which carried out hydrogenation / which was obtained with hydrogen gas] -1, and 1-dimethanol 474g, 405g of dimethyl carbonate, and 1.4g of potassium carbonate were put in, and it reacted for 14 hours, distilling off the methanol which carries out heating stirring and which is generated at the temperature of 100 degrees C among an oil bath out of a system by ordinary pressure. Finally the inside of a reaction container was made reduced pressure to 10mmHg(s), and the corresponding carbonate was obtained at 95% of yield.

[0092] It reacted for 10 hours, having carried out heating stirring of the obtained annular carbonate at 250 degrees C as it was, and discharging the produced carbon dioxide gas out of a system from the upper part of a cooling system. Distillation purification of this reaction solution was carried out, and CHO230g was obtained.

[0093] The 2-phenylcyclohexane-1 and 1-dimethanol which are obtained by carrying out hydrogenation of the Diels-Alder resultant of a butadiene and trans-cinnamaldehyde with hydrogen gas instead of the 2-methylcyclohexane-1 used by composition of <composition of 2-OKISA-5-phenyl SUPIRO [3.5] nonane (PCHO)> CHO and 1-dimethanol by making 5% palladium / activated carbon into a catalyst in toluene were used, and this invention person compounded with the same procedure as the above.

[0094] Instead of the 6-methyl-3-cyclohexene-1 obtained from the Diels-Alder reactant of a butadiene and a crotonaldehyde used at the time of <composition of spiro [bicyclo [2.2.1] heptane-2 and 3'-oxetane] (NRBO)> CHO composition, and 1-dimethanol 5% palladium / activated carbon is made into a catalyst for a cyclopentadiene, the bicyclo [2.2.1] hepta-5-en-1 which is the resultant of an acrolein, and 1-dimethanol in toluene. With hydrogen gas this invention person compounded with the same procedure as the above by completely performing the same reaction using the bicyclo [2.2.1] heptane-1 and 1-dimethanol which carried out hydrogenation.

[0095] <Composition (fluorination epoxy resin A) which is diglycidyl ether which is a bis(1, 1, 1, 3, 3, and 3-hexafluoro isopropyl) cyclohexane> [Formula 12]



Macromolecules It compounded according to 1996, 29, and 2006-2010. Obtained fluorination epoxy resin A used the mixture of 15% of things whose things of 0 are [n of a repeat unit] 1, 85% of things which are 3, and 1 and 4 for association of 100% and a cyclohexane.

[0096] <examples 1-8 and the examples 1-3 of a comparison> — the photoresist of the constituent for optical waveguide resin was examined first. The oxetane compound, the epoxy compound, the optical cationic initiator, etc. were mixed by the combination (the numeric value of front Naka is the mass section) shown in Table 1, and each constituent for optical waveguide resin was obtained.

[0097] Thus, about each obtained constituent for optical waveguide resin, as it was the following, the photo-curing sex test was performed. On the glass substrate, the thickness of a constituent layer was applied so that it might be set to 100 micrometers. Then, it irradiated for 10 seconds with the output of 24 mW/cm² using the metal halide lamp, and the constituent layer was hardened. The condition of the tuck of the hardened constituent layer is investigated by the fingertip, and the obtained result is shown in Table 1. Here, when there was no tuck in a hardened material layer, there was a tuck a little and “**” and a tuck existed [“O” and], it was described as “x.”

[0098] Although it is the mixture of an alicyclic compound (a) and an epoxy compound which has the OKISETANIRU radical of this invention, as for examples 1-8, it turns out that it excels in hardenability.

[0099] On the other hand, although the example 1 of a comparison was the constituent of only an epoxy compound, it did not harden at all but the remarkable tuck was shown. Moreover, the examples 2 and 3 of a comparison are examples using the oxetane compound which does not have alicyclic structure as an oxetane compound. Although the improvement in hardenability was checked compared with the constituent of only an epoxy compound, as compared with the example which mixed the alicyclic compound (a) which has the OKISETANIRU radical of this invention, hardenability was a little inferior. To the oxetane compound of this invention, although the example 4 was a mixed example of other oxetane compounds, it was hardened enough. The hardenability of the alicyclic compound (a) which has the OKISETANIRU radical of this invention is reflected. Moreover, in the example 5, although it was the example which mixed the radical polymerization initiator with the radical polymerization nature compound, this example was also hardened enough.

[0100] Thus, it turns out that the constituent for optical waveguide resin containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention is excellent in hardenability.

[0101] Furthermore, about the thing after full hardening of each obtained constituent for optical waveguide resin (light was irradiated further and it was made to harden completely), the refractive index to the D line of the sodium in 25 degrees C was measured, and the result was shown in Table 1. The refractive index was measured with the Abbe refractive-index plan (Atago Co., Ltd. Abbe refractive-index total 1 mold). As for the refractive index, it turned out that it can change with 1.465 to 1.550 and can adjust as a constituent for the object for the clad sections, and the core sections.

[0102]

[Table 1]

	実施例								比較例			
	化合物	1	2	3	4	5	6	7	8	1	2	3
オキセタン化合物(a)	CHO	20										
	CHEO		30									
	PCHO								10			
	NRBO					10						
	ECHO			50	50	40	30	25				
	EECHO							25				
その他のオキセタン化合物	EFCHO								10			
	POX										30	
	XDO				10				10			50
エポキシ化合物	ゼロキサイド3000											
	KRM-2110	50	40				30		30	80	40	
	エピコート828	30	30	50	40		20	50		10	30	50
	フッ素化エポキシ樹脂A					50			40			
ラジカル重合性化合物	M-309						5					
	3000A						15					
光カチオン重合開始剤	UVI-6990	3	3	3	3	3	3	3	3	3	3	3
光ラジカル開始剤	イルガキュ7907						↑					
光硬化性	O	O	O	O	O	O	O	O	x	△	△	
硬化後の屈折率	1.532	1.531	1.547	1.505	1.465	1.498	1.550	1.480	1.523	1.571	1.569	

[0103] The thermosetting of the constituent examples 9–11 and for <examples 4–6 of comparison> optical waveguide resin was examined. Each constituent for optical waveguide resin was similarly adjusted except having changed the optical cationic initiator of examples 1–8 and the examples 1–3 of a comparison into heat cationic initiator SI-60L. The (mass section) is shown for loadings in Table 2.

[0104] Thus, about each obtained constituent for optical waveguide resin, as it was the following, the heat-curing sex test was performed. The class product was put in into the sample bottle and it soaked in the 80-degree C oil bath. Thermosetting was judged as follows about the description of the class product after hardening for 1 minute. It is [“**” and the thing of “x” and the thing currently thickened which is carrying out full hardening] “O which viscosity has hardly changed and carried out.”

[0105] The result was shown in Table 2. Thermosetting is [constituent / containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention / an epoxy compound independent or other oxetane compounds] remarkably high.

[0106] Although heat curing could also be used if needed in the clad section of optical waveguide, it turned out that the constituent for optical waveguide resin of this invention has sufficient hardenability also in heat curing.

[0107]

[Table 2]

		実施例			比較例		
	化合物	9	10	11	4	5	6
オキセタン化合物(a)	CHO	20					
	CHEO		30				
	ECHO			50			
その他のオキセタン化合物	POX					30	
	XDO						50
エポキシ化合物	ゼロキサイド3000				10		
	KRM-2110	50	40		80	40	
	エピコート828	30	30	50	10	30	50
熱カチオン重合開始剤	SI-60L	3	3	3	3	3	3
熱硬化性	O~△	O~△	O	x	△	△	

[0108] Example of manufacture and constituent ECHO for the clad sections of <example 12> optical waveguide 40 mass sections, 2110 Ten mass sections, 828 Ten mass sections, optical cationic initiator UVI-6990 Three mass sections were mixed so that it might become homogeneity enough. Furthermore, the constituent for the optical waveguide clad sections was obtained by filtering and removing dust etc. In addition, the thing of the same name of article as what was stated in the examples 1–8 was used for each ingredient.

[0109] – Constituent ECHO for the core sections 30 mass sections, 2110 Ten mass sections, 828 60 mass sections, optical cationic initiator UVI-6990 Three mass sections were mixed so that it might become homogeneity enough. Furthermore, the constituent for the optical

waveguide core sections was obtained by filtering and removing dust etc. In addition, the thing of the same name of article as what was stated in the examples 1–8 was used for each ingredient.

[0110] Next, manufacture of optical waveguide is explained. As shown in drawing 1 (A), the substrate 10 which consists of silicon was prepared and constituent layer 11a which consists of a constituent for the optical waveguide clad sections was formed with the spin coat method the whole surface on this substrate 10. Then, as shown in drawing 1 (B), the ultraviolet rays of 2500 mJ/cm² were irradiated using the extra-high pressure mercury lamp to constituent layer 11a. The clad section 11 was formed by hardening constituent layer 11a (drawing 1 (C)). At this time, the thickness of the clad section 11 was 30 micrometers. Moreover, it was 1.512 when the refractive index of the clad section 11 to the D line of the sodium in 25 degrees C was measured.

[0111] Next, as shown in drawing 1 (D), on the clad section 11, the spin coat method was used and constituent layer 12a was formed by applying the constituent for the optical waveguide core sections.

[0112] Furthermore, it has arranged so that 100 micrometers of photo masks 21 which have opening of the shape of a stripe whose width of face is 30 micrometers may be estranged from the front face of a substrate 10, and the ultraviolet rays of 1500 mJ/cm² were irradiated to constituent layer 12a through this photo mask 21 using the extra-high pressure mercury lamp (the pro squeak tee exposing method). Part 12a1 corresponding to [as this showed drawing 1 (E)] opening of the photo mask of constituent layer 12a The constituent for the optical waveguide core sections which constitutes constituent layer 12a then hardened. At this time, the thickness of hardened constituent layer 12a was 30 micrometers. Moreover, when the refractive index to the D line of the sodium in 25 degrees C was measured, it was 1.558, and the refractive-index difference with the clad section 11 was 0.046.

[0113] After irradiating ultraviolet rays, ultraviolet rays are not irradiated with a photo mask 21, but it is the part 12a2 in the condition of not hardening. Dissolution removal was carried out with the acetone. Then, hardened material layer 12a (12a1) was washed using isopropyl alcohol. Thus, as shown in drawing 1 (F), two or more core sections 12 with a beltlike flat-surface configuration were formed.

[0114] Finally, as shown in drawing 1 (G), the clad section 13 was formed by the same approach as the clad section 11 on the exposure of the clad section 11, and the core section 12 using the same constituent as the clad section 11, and the optical waveguide of an embedding mold was produced.

[0115] <Example 13> width of face produced optical waveguide like the example 12 except for having formed the core section with a width of face of 50 micrometers using the photo mask 21 (refer to drawing 1 (D)) which has opening of the shape of a stripe which is 50 micrometers.

[0116] <Example 14> width of face produced optical waveguide like the example 12 except for having formed the core section with a width of face of 70 micrometers using the photo mask 21 which has opening of the shape of a stripe which is 70 micrometers.

[0117] Thus, about the optical waveguide of the acquired examples 12–14, the trial about optical transmission loss was performed, respectively. This trial used the wavelength of 790nm, and 650nm semiconductor laser, and measured the propagation loss in TE (Transverse Electro) mode and TM (Transverse Magnetic) mode by the cutting-back method (how to measure the output power of optical waveguide, while cutting optical waveguide short gradually). The obtained result is shown in Table 3.

[0118] In addition, the TE mode is the mode in which an electric-field component exists only in the cross section of optical waveguide, and it has a field component in the optical propagation direction. Moreover, the TM mode is the mode in which a field component exists only in the cross section of optical waveguide, and it has an electric-field component in the optical propagation direction.

[0119] As shown also in Table 3, also in which the mode of the TE mode and the TM mode, the small value of 0.22–0.37dB/cm was acquired, and the optical waveguide of examples 12–14 was a good thing which has few optical transmission loss.

[0120]

[Table 3]

測定波長 (nm)	伝搬モード	光伝搬損失(dB/cm)		
		実施例12	実施例13	実施例14
790	TEモード	0.26	0.25	0.23
	TMモード	0.25	0.23	0.22
650	TEモード	0.35	0.37	0.34
	TMモード	0.34	0.35	0.33

[0121]

[Effect of the Invention] the constituent for optical waveguide resin containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention — optical cation hardening and heat cation hardening — in any case, reactivity can be high and hardening can be quickly advanced to it.

[0122] Moreover, by mixing with an epoxy compound or other oxetane compounds, the alicyclic compound (a) which has the OKISETANIRU radical of this invention can change a refractive index, and can build to arbitration the constituent the core section from which a refractive index differs, respectively, and for the clad sections.

[0123]

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] This invention relates to the optical relation ingredient which used the optical waveguide for the hardenability constituent for forming the optical waveguide to which a lightwave signal can spread the interior and the optical waveguide which hardened the constituent and was obtained, and a list.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] By advance of the technique in IC (Integrated circuit; integrated circuit) or LSI (Large Scale Integration; large-scale integrated circuit), those working speeds and accumulation scales improve and high-performance-izing of a microprocessor and large capacity-ization of a memory chip are attained quickly. between the chips between the boards in the former and a device, or in a board etc. — signal transduction between short distance has mainly been comparatively performed by the electrical signal. In order to raise the engine performance of an integrated circuit further from now on, the further improvement in the speed of a signal and the densification of signal wiring are needed, but in electrical signal wiring, while these improvement in the speed and densification are reaching a limitation, the signal delay by CR (C: electrostatic-capacity [of wiring], resistance of R:wiring) time constant of wiring poses a problem. Moreover, since improvement in the speed of an electrical signal and the densification of electrical signal wiring cause an EMI (Electromagnetic Interference) noise, they become indispensable [the cure].

[0003] Then, optical wiring (optical interconnection) attracts attention as what solves these problems. Optical wiring is considered [that it is applicable to various parts, such as between the chips between the boards between devices and in a device, or in a board, and]. Especially, optical waveguide is formed on the substrate in which the chip is carried, and it is considered suitable by transmission of the signal between short distance like [during a chip] to build the optical transmission and communication system which made this the transmission line.

[0004] The waveguide used here can be used for optical devices used for the optic field in addition to optical wiring, such as optical passive components, optical circuit components, etc., such as an optical switch, a fiber optic connector, an optical spectral separation multiplexing machine, an optical spectral separation coupler, an optical attenuator, and an optical isolator. About these light device, publication and p.161-175 will have a publication in "newest commercial scene of transparent plastic" CMC publication 1999. Hereafter, all the things about the waveguide used for an optical relation ingredient are summarized as optical waveguide, and are indicated.

[0005] Conventionally, inorganic glass, such as a quartz, was used as this kind of optical waveguide. However, since it was necessary to perform heat treatment by the elevated temperature to form optical waveguide using inorganic glass, heat-treating under the elevated temperature of a semi-conductor substrate, a plastic plate, etc. was not able to form optical waveguide on the difficult substrate.

[0006] On the other hand, optical waveguide using polymeric materials is being proposed and put in practical use in recent years. Polymeric materials are easy to process it as compared with an inorganic material, and can perform large-area-izing and film-ization easily. Moreover, since it is flexible, it has various advantages, like that an application is large and adjustment of a refractive index is easy. Especially, since it is the ingredient which can be mass-produced, the resin of an ultraviolet curing mold is expected as an ingredient for optical waveguides. As resin of such an ultraviolet curing mold, the epoxy resin is known widely.

[0007] The optical waveguide using an epoxy resin is formed by performing the development which carries out wet etching of the part for the non-hard spot of resin, after applying resin on a

support base and carrying out selection exposure of the resin generally.

[0008] However, since the polymerization nature of an epoxy resin was low, when optical waveguide was formed using an epoxy resin, it had the problem that a lot of energy is required in case resin is stiffened, and productive efficiency will worsen.

[0009] On the other hand, it is known by mixing an oxetane compound with an epoxy compound that cation hardening will improve remarkably. Since it is such, although the constituent for optical waveguide resin which used these oxetane compound is shown, in order to actually use for optical waveguide, in JP,2000-356720,A, the present condition is being unable to say that it has sufficient cure rate.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] the constituent for optical waveguide resin containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention — optical cation hardening and heat cation hardening — in any case, reactivity can be high and hardening can be quickly advanced to it.

[0122] Moreover, by mixing with an epoxy compound or other oxetane compounds, the alicyclic compound (a) which has the OKISETANIRU radical of this invention can change a refractive index, and can build to arbitration the constituent the core section from which a refractive index differs, respectively, and for the clad sections.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention is made in view of this trouble, and it is in offering the optical waveguide which used it for the constituent for optical waveguide resin excellent in polymerization nature, and the list, and its manufacture approach.

[Translation done.]

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MEANS

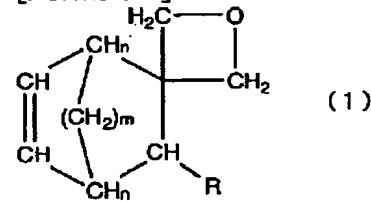
[Means for Solving the Problem] this invention persons came to complete a header and this invention for the ability of the constituent for optical waveguide resin containing a specific cationic polymerization nature compound and the compound which makes cationic polymerization start with an exposure and/or heating of an activity energy line to solve said technical problem, as a result of considering solution of the above-mentioned technical problem wholeheartedly.

[0012] That is, this invention relates to the optical waveguide which used it for the constituent for optical waveguide resin shown in the following [1] - [19], and the list, and its manufacture approach.

[0013] [1] The constituent for optical waveguide resin characterized by including the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular.

[0014] [2] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (1).

[Formula 4]

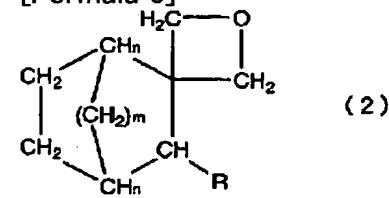


((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1-12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0-2, and the inside R of a formula is 1 except it.)

[3] The constituent for optical waveguide resin given in [2] characterized by the compound shown by the general formula (1) being a 2-oxaspiro [3.5] nona-6-en or a 5-methyl-2-oxaspiro [3.5] nona-6-en.

[0015] [4] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (2).

[Formula 5]



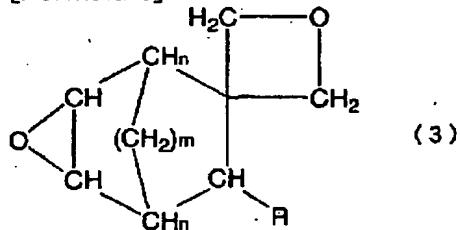
((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1-12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0-2, and the inside R of a formula is 1 except it.)

[5] The constituent for optical waveguide resin given in [4] characterized by the compound

shown by the general formula (2) being 2-oxaspiro [3.5] nonane or a 5-methyl-2-oxaspiro [3.5] nonane.

[0016] [6] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by being the compound expressed by the general formula (3).

[Formula 6]



((n is 2 when m is 0.) It is each radical of a hydrogen atom or the alkyl group of carbon numbers 1–12, an aryl group, an aralkyl radical, and an alkyl halide radical, m is the integer of 0–2, and the inside R of a formula is 1 except it.)

[0017] [7] The constituent for optical waveguide resin given in [6] to which the compound shown by the general formula (3) is characterized by being a 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane, 6, and 7-epoxy-2-oxaspiro [3.5] nonane.

[8] The constituent for optical waveguide resin given in [1] to which the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in intramolecular is characterized by the thing which was chosen from the compound expressed with a general formula (1), a general formula (2), and a general formula (3), and which is a kind at least.

[9] The constituent for optical waveguide resin of any one publication of [1] – [8] characterized by containing the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical.

[0018] [10] The constituent for optical waveguide resin given in [9] characterized by the compound (b) which has an epoxy group more than a piece and does not have an OKISETANIRU radical having a fluorine atom.

[11] The constituent for optical waveguide resin of any one publication of [1] – [10] characterized by including the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line.

[12] The constituent for optical waveguide resin given in [11] which is one or more sorts as which the compound (c) which makes cationic polymerization start with an exposure and/or heating of an activity energy line was chosen from sulfonium salt, iodonium salt, phosphonium salt, and diazonium salt.

[0019] [13] The constituent for optical waveguide resin of any one publication of [1] – [12] characterized by including a radical polymerization nature compound (d).

[14] The constituent for optical waveguide resin of any one publication of [1] – [13] characterized by including an optical radical initiator (e).

[15] The constituent for optical waveguide resin of any one publication of claim 1–14 with which the refractive index to the D line of the sodium in 25 degrees C of a hardened material is characterized by being a value within the limits of 1.70 or less [1.40 or more].

[0020] [16] [1] Optical waveguide which was made to harden the constituent for optical waveguide resin of any one publication of – [15], and was obtained.

[17] Optical waveguide characterized by for either [at least] the core section or the clad section hardening the constituent for optical waveguide resin of any one publication of [1] – [15], and obtaining it while having the core section and the clad section.

[0021] [18] The manufacture approach of the optical waveguide which forms optical waveguide by the development which is made to harden the constituent concerned alternatively and removes a part for a non-hard spot by irradiating an activity energy line alternatively at the layer using the constituent for optical waveguide resin containing the compound (c) which makes intramolecular start cationic polymerization with the exposure and/or heating of an alicyclic

compound (a) and an activity energy line which have the OKISETANIRU radical of a piece at least.

[19] The optical device with which the optical waveguide of a publication was used for [16].

[0022]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail.

[0023] the alicyclic compound (a) which has the OKISETANIRU radical of a piece at least in the same intramolecular of this invention — (— it abbreviates to a compound (a) henceforth. The alicyclic compound expressed with a general formula (1), a general formula (2), or a general formula (3) as) is desirable. a general formula (1), (2), and (3) — setting — R — each of each type — it is each radical of the alkyl group of a hydrogen atom, the shape of a straight chain of carbon numbers 1–12, and the letter of branching, an aryl group, an aralkyl radical, and an alkyl halide radical independently. In these, a hydrogen atom and the alkyl group of a straight chain are desirable, and a hydrogen atom and especially a methyl group are desirable. n is 2 when m is 0, and m is the integer of 0–2 and it is 1 except it. It means that a bridging with a methylene chain does not exist in m= 0.

[0024] As the alkyl group of the shape of a straight chain of carbon numbers 1–12, and the letter of branching, an aryl group, and an aralkyl radical, a methyl group, an ethyl group, an isopropyl group, a phenyl group, benzyl, etc. are mentioned.

[0025] As an alkyl halide radical, a fluoro alkyl group, a chloro alkyl group, a BUROMO alkyl group, etc. are mentioned. Each [these] alkyl group is the shape of a straight chain, and a letter of branching, and the number of each halogen atoms should just be one or more.

[0026] As a compound expressed with a general formula (1), a 2-oxaspiro [3.5] nona-6-en, A 9-methyl-2-oxaspiro [3.5] nona-6-en, 2 - OKISA-9-phenyl SUPIRO [3.5] nona-6-en, a 9-trifluoromethyl-2-oxaspiro [3.5] nona-6-en and spiro — [the bicyclo [2.2.1] hepta—5-en -2, 3'-oxetane], and spiro — [the 3-methyl bicyclo [2.2.1] hepta—5-en -2, 3'-oxetane], etc. are mentioned. In these, a 2-oxaspiro [3.5] nona-6-en and a 9-methyl-2-oxaspiro [3.5] nona-6-en are desirable.

[0027] These compounds have the OKISETANIRU radical and the carbon carbon double bond, were excellent not only in cationic polymerization nature but radical polymerization nature, and are contributed to improvement in a cure rate. Moreover, since it has alicycle structure, the hardened material of the constituent of this invention is excellent also in thermal resistance. Furthermore, since many of compounds shown by the general formula (1) are liquids in ordinary temperature, it becomes possible [lowering the viscosity of the constituent of this invention], and may raise coating nature.

[0028] As a compound expressed with a general formula (2), 2-oxaspiro [3.5] nonane, A 7-methyl-2-oxaspiro [3.5] nonane, a 5-methyl-2-oxaspiro [3.5] nonane, A 2-OKISA-5-phenyl SUPIRO [3.5] nonane, a 5-trifluoromethyl-2-oxaspiro [3.5] nonane, spiro — [adamantane -2, 3'-oxetane], and spiro — [the bicyclo [2.2.1] heptane -2 and 3'-oxetane] — spiro — [— bicyclo one — [— 2.2.2 —] — an octane — two — three — ' - oxetane —] — spiro — [— seven — OKISA — bicyclo one — [— 2.2.1 —] — a heptane — two — three — ' - oxetane —] — spiro — [— three — methyl — bicyclo one — [— 2.2.1 —] — a heptane — two — three — ' - oxetane —] — etc. — mentioning — having . In these, 2-oxaspiro [3.5] nonane and a 5-methyl-2-oxaspiro [3.5] nonane are desirable.

[0029] These compounds are excellent in cationic polymerization nature, and have the effectiveness of the improvement in a cure rate of a constituent. Moreover, the alicycle structure gives thermal resistance to the hardened material of the constituent of this invention. Furthermore, since many of compounds shown by the general formula (2) are liquids in ordinary temperature, it becomes possible [lowering the viscosity of the constituent of this invention], and may raise coating nature.

[0030] As a compound expressed with a general formula (3), 7, a 8-epoxy-5-methyl-oxaspiro [3.5] nonane, 7, a 8-epoxy-5-ethyl-2-oxaspiro [3.5] nonane, 7, a 8-epoxy-2-OKISA-5-phenyl SUPIRO [3.5] nonane, 7, 8 oxaspiro [— epoxy-5-truffe RIORO methyl-2-] [3.5] nonane, six — seven — epoxy — two — oxaspiro — [— 3.5 —] — a nonane — spiro — [— five — six — epoxy —

- norbornane - two - three - ' - oxetane -] - spiro - [- five - six - epoxy - three - methyl - norbornane - two - three - ' - oxetane -] - etc. - it is . In these, a 7 and 8- epoxy-5-methyl-2-oxaspiro [3.5] nonane, 6, and 7-epoxy-2-oxaspiro [3.5] nonane is desirable. [0031] These compounds had the OKISETANIRU radical and the epoxy group simultaneously, were excellent in cationic polymerization nature, and are contributed to improvement in the cure rate of a constituent. Moreover, it has alicycle structure and the thermal resistance of a hardened material is raised.

[0032] Compounds (a) including the alicyclic compound which has an OKISETANIRU radical more than a piece in the intramolecular expressed with a general formula (1), (2), and (3) are independent; or can be used as two or more sorts of mixture. the loadings (when using two or more sorts together, they are those total quantities) of these compounds (a) — the inside of the constituent for optical waveguide resin of this invention — desirable — 1 - 90 mass % — it is 10 - 60 mass % still more preferably.

[0033] As a compound (b) which has an epoxy group more than a piece in the intramolecular of this invention, and does not have an OKISETANIRU radical, the epoxy compound of well-known common use can be used. This epoxy compound will not be limited, especially if it has an epoxy group more than a piece in 1 molecule and does not have an OKISETANIRU radical.

[0034] Specifically Bisphenol A diglycidyl ether, bisphenol F diglycidyl ether, Bisphenol S diglycidyl ether, bromination bisphenol A diglycidyl ether, Bromination bisphenol F diglycidyl ether, bromination bisphenol S diglycidyl ether, a novolak mold epoxy resin (for example, a phenol novolak mold epoxy resin —) A cresol novolak mold epoxy resin, a bromination phenol novolak mold epoxy resin, Hydrogenation bisphenol A diglycidyl ether, hydrogenation bisphenol F diglycidyl ether, hydrogenation bisphenol S diglycidyl ether, triglycidyl isocyanurate, etc. can be used.

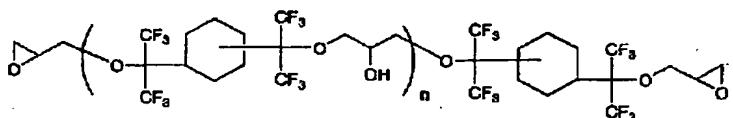
[0035] Moreover, it is methyl (3, 4-epoxycyclohexyl) as an aliphatic series epoxy compound. - 3', 4'-epoxycyclohexyl carboxylate, 2-(3, 4-epoxycyclohexyl -5, 5-spiro -3, 4-epoxy) cyclohexane-meta-dioxane, A bis(3, 4-epoxycyclohexyl methyl) horse mackerel peat, vinyl cyclohexene oxide, 4-vinyl epoxy cyclohexane, a bis(3, 4-epoxy-6-methylcyclohexyl methyl) horse mackerel peat, 3, 4-epoxy-6-methylcyclohexyl - 3', 4 '- epoxy -6'-methylcyclohexane carboxylate, Methylenebis (3, 4-epoxy cyclohexane), dicyclopentadiene diepoxide, Limonene diepoxide, the JI (3, 4- epoxycyclohexyl methyl) ether of ethylene glycol, and an ethylene screw (3, 4-epoxy cyclohexane carboxylate) are mentioned.

[0036] Furthermore, epoxy hexahydrophthalic acid dioctyl, epoxy hexahydrophthalic acid G 2-ethylhexyl, 1,4-butanediol diglycidyl ether, 1, 6-hexanediol diglycidyl ether, Glycerol triglycidyl ether, trimethylolpropane triglycidyl ether, Polyethylene glycol diglycidyl ether, polypropylene glycol diglycidyl ether, Ethylene glycol, propylene glycol, By adding one sort or two sorts or more of alkylene oxide to aliphatic series polyhydric alcohol, such as a glycerol The monoglycidyl ether of the diglycidyl ether; aliphatic series higher alcohol of the Pori glycidylethers; aliphatic series long-chain dibasic acid of the polyether polyol obtained; Butyl glycidyl ether, Phenyl glycidyl ether, KUREZORU glycidyl ether, nonylphenyl glycidyl ether, Glycidyl methacrylate; A phenol, cresol, Glycidyl ester; epoxidized soybean oil of a monoglycidyl ether; higher fatty acid of the polyether alcohol which adds alkylene oxide to butylphenol or these, and is obtained; Epoxy butyl stearate, Epoxy stearin acid octyl, the epoxidation linseed oil, epoxidation polybutadiene, etc. can be mentioned.

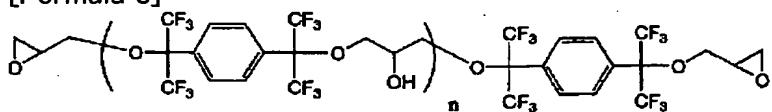
[0037] In order to adjust the refractive index of the optical waveguide of this invention furthermore, the fluorination epoxy compound which has a fluorine atom can be used. A fluorination epoxy compound can be adjusted to a desired refractive index by having a small refractive index as compared with the hydrocarbon mold epoxy compound which has the same structure, and mixing to the resin constituent for optical waveguides.

[0038] Although the example of the following compound is specifically indicated by "volume [of application physics / 68th] No. 1 (1999), and p.4-13", this invention is not limited to these.

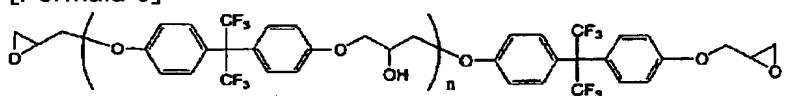
[Formula 7]



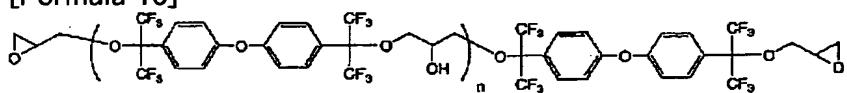
[Formula 8]



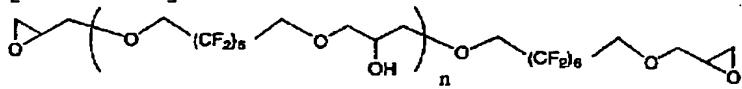
[Formula 9]



[Formula 10]



[Formula 11]



[0039] The compound (b) which has an epoxy group more than a piece in these intramoleculars, and does not have an OKISETANIRU radical is independent, or two or more sorts can use it, mixing.

[0040] The sum total of a compound [in / in the loadings (when using two or more sorts together, they are those total quantities) of a compound (b) / this invention] (a): The 1 – 10,000 mass section is desirable to the 100 mass sections, and especially the 10 – 1,000 mass section is desirable.

[0041] The compound (c) which makes cationic polymerization start with the exposure and/or heating of an activity energy line as used in the field of this invention can change with the exposures of activity energy lines, such as heating and ultraviolet rays, and can be used as the compound which generates the matter which makes cationic polymerization, such as an acid, start. Therefore, a compound (c) is a kind of cationic initiator, and is also called the "acid generator" in this industry. Henceforth, in this invention, a compound (c) is also called an acid type-of-seasonal-prevalence cationic initiator.

[0042] By the optical exposure of heating or ultraviolet rays, an acid type-of-seasonal-prevalence cationic initiator promotes the cationic polymerization of the compound (a) of this invention, a compound (b), and other cationic polymerization nature matter (compound containing an OKISETANIRU radical etc.), and advances smoothly hardening of the constituent for optical waveguide resin of this invention.

[0043] Moreover, the acid type-of-seasonal-prevalence cationic initiator as used in the field of this invention changes with the exposures of activity energy lines, such as heating and ultraviolet rays, it is the compound which generates the matter which makes cationic polymerization, such as an acid, start, and the compound which has taken the form of an acid from the beginning like a carboxylic acid is not contained.

[0044] Sulfonium salt well-known as an acid type-of-seasonal-prevalence cationic initiator, iodonium salt, phosphonium salt, diazonium salt, ammonium salt, and ferrocenes are mentioned. Although illustrated concretely below, it is not limited to these compounds.

[0045] As an acid type-of-seasonal-prevalence cationic initiator of a sulfonium salt system Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Screw hexafluorophosphate, Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Screw hexafluoroantimonate, Screw [4-(diphenyl SURUHONIO)

phenyl] sulfide screw tetrafluoroborate, Bis[4-(diphenyl SURUHONIO) phenyl] sulfide Tetrakis (pentafluorophenyl) borate, Diphenyl-4-(phenylthio) phenyl sulfonium Hexafluorophosphate, Diphenyl-4-(phenylthio) phenyl sulfonium Hexafluoroantimonate, Diphenyl-4-(phenylthio) phenyl sulfonium tetrafluoroborate, Diphenyl-4-(phenylthio) phenyl sulfonium Tetrakis (pentafluorophenyl) borate, Triphenylsulfonium hexafluorophosphate, triphenylsulfonium hexafluoroantimonate, Triphenylsulfonium tetrafluoroborate, triphenylsulfonium tetrakis (pentafluorophenyl) borate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw hexafluorophosphate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw hexafluoroantimonate, Bis[4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide Screw tetrafluoroborate, Screw [4-(JI (4-(2-hydroxy ethoxy)) phenyl SURUHONIO) phenyl] sulfide tetrakis (pentafluorophenyl) borate etc. is mentioned.

[0046] As an acid type-of-seasonal-prevalence cationic initiator of an iodonium salt system Diphenyliodonium Hexafluorophosphate, diphenyliodonium Hexafluoroantimonate, Diphenyliodonium Tetrafluoroborate, diphenyliodonium Tetrakis (pentafluorophenyl) borate, Bis(dodecyl phenyl) iodonium Hexafluorophosphate, Bis(dodecyl phenyl) iodonium Hexafluoroantimonate, Bis(dodecyl phenyl) iodonium Tetrafluoroborate, Bis(dodecyl phenyl) iodonium Tetrakis (pentafluorophenyl) borate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Hexafluorophosphate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Hexafluoroantimonate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium tetrafluoroborate, 4-methylphenyl-4-(1-methylethyl) phenyliodonium Tetrakis (pentafluorophenyl) borate etc. is mentioned.

[0047] As an acid type-of-seasonal-prevalence cationic initiator of a phosphonium salt system, ethyltriphenylphosphonium tetrafluoroborate, ethyltriphenylphosphonium hexafluorophosphate, ethyltriphenylphosphonium hexafluoroantimonate, tetrabutyl phosphonium tetrafluoroborate, tetrabutyl phosphonium hexafluorophosphate, tetrabutyl phosphonium hexafluoroantimonate, etc. are mentioned.

[0048] As an acid type-of-seasonal-prevalence cationic initiator of a diazonium salt system, it is phenyl diazonium Hexafluorophosphate, phenyl diazonium Hexafluoroantimonate, phenyl diazonium Tetrafluoroborate, phenyl diazonium Tetrakis (pentafluorophenyl) borate etc. is mentioned.

[0049] As an acid type-of-seasonal-prevalence cationic initiator of an ammonium salt system 1-benzyl-2-cyano pyridinium Hexafluorophosphate, 1-benzyl-2-cyano pyridinium Hexafluoroantimonate, 1-benzyl-2-cyano pyridinium Tetrafluoroborate, 1-benzyl-2-cyano pyridinium tetrakis (pentafluorophenyl) borate, 1-(naphthyl methyl)-2-cyano pyridinium Hexafluorophosphate, 1-(naphthyl methyl)-2-cyano pyridinium Hexafluoroantimonate, 1-(naphthyl methyl)-2-cyano pyridinium Tetrafluoroborate, 1-(naphthyl methyl)-2-cyano pyridinium Tetrakis (pentafluorophenyl) borate etc. is mentioned.

[0050] As an acid type-of-seasonal-prevalence cationic initiator of a ferrocene system [(1-methylethyl) benzene]-Fe (II) hexafluorophosphate, (2, 4-cyclopentadiene-1-IRU) [(1-methylethyl) benzene]-Fe (II) hexafluoroantimonate, (2, 4-cyclopentadiene-1-IRU) 2, 4-cyclopentadiene-1-IRU [(1-methylethyl) benzene]-Fe (II) tetrafluoroborate, 2, 4-cyclopentadiene-1-IRU [(1-methylethyl) benzene]-Fe(II) tetrakis (pentafluorophenyl) borate, etc. are mentioned.

[0051] In these acid type-of-seasonal-prevalence cationic initiators, the initiator of sulfonium salt and an iodonium salt system is desirable from the field of a cure rate, stability, and economical efficiency. As a commercial item SAN-AID SI[by the CI-2639; 3 Japanese Federation of Chemical Industry Workers' Unions industrial company]-60; SP[by Asahi Denka Kogyo K.K.]- 150, SP-170, CP-66, CP-77; Union Carbide CYRACURE-UVI -6990, and UVI-6974; Nippon Soda Co., Ltd. make — CI-2855 — "The IRUGA cure 261" (Ciba Specialty Chemicals [(1-methylethyl) benzene] (2, 4-cyclopentadiene-1-IRU)-Fe (II) hexafluorophosphate), "Load sill (RHODORSIL) 2074"; (Rhone-Poulenc shrine 4-methylphenyl-4-(1-methylethyl) phenyliodonium tetrakis (pentafluorophenyl) borate) etc. is mentioned.

[0052] These acids type-of-seasonal-prevalence cationic initiator can be chosen from the ingredients mentioned above, can also be used independently, and can also be used combining two or more kinds. although especially the range where the amount of the acid type-of-

seasonal-prevalence cationic initiator used is suitable does not have a limit — the loadings (total quantity which united them when compound in which other below-mentioned cationic polymerization is possible was used together) 100 mass section of the sum total of a compound (a) and a compound (b) — receiving — 0.05 – 25 mass section — it is 1 – 20 mass section preferably. If there are few additions than the 0.05 mass section, in order to become a defect of sense and to fully harden, high temperature processing of remarkable optical big exposure energy or long duration is required. Moreover, even if it adds exceeding 25 mass sections, improvement in sensibility is not carried out and is not economically desirable. Conversely, there is a possibility that the amount which remains as a non-hardened component may increase and the physical properties of a hardened material may fall into a constituent.

[0053] The cationic polymerization nature monomer shown below in this invention can also be added to the constituent for optical waveguide resin of this invention in the range which does not affect hardenability and hardened material physical properties. This cationic polymerization nature monomer is classified into the compound which is a compound which causes a polymerization initiation reaction and crosslinking reaction with the acid which the acid type-of-seasonal-prevalence cationic initiator generated, and is except a compound (a) and a compound (b). For example, trimethylene oxide, 3, and 3-dimethyl oxetane, 3, and 3-dichloro methyl oxetane, 3-ethyl-3-phenoxyethyl oxetane, 3-ethyl-3-hydroxymethyloxetane (Toagosei make; trade name EOXA), Bis[(3-ethyl-3-OKISETA nil methoxy) methyl] benzene (alias name xylylene JIOKI cetane; Toagosei; trade name XDO), Tori [(3-ethyl-3-OKISETA nil methoxy) methyl] benzene, The bis[(3-ethyl-3-OKISETA nil methoxy) methylphenyl] ether, 3-ethyl-3-[(oxy-RANIRU methoxy) methyl] oxetane, The oxetane compound to which the OKISETANIRU radical is attached in addition to alicyclic compounds, such as oligo dimethylsiloxane; A tetrahydrofuran, (3-ethyl-3-OKISETA nil methoxy) Oxo-run compounds, such as 2 and 3-dimethyl tetrahydrofuran; A trioxane, Annular acetal compounds, such as 1, 3-dioxolane, 1 and 3, and 6-trioxane cyclooctane; Beta propiolactone, Annular lactone compounds, such as epsilon-caprolactone; An ethylene sulfide, Thiethane compounds, such as thiirane compound; 3, such as 1, 2-propylene sulfide, and thio epichlorohydrin, and 3-dimethyl thiethane; The ethylene glycol divinyl ether, The SUPIRO orthochromatic ester compound which is a resultant of a vinyl ether compound; epoxy compound and lactone, such as the TORIECHIRENGURI COL divinyl ether and the trimethylol propane TORIBI nil ether; A vinyl cyclohexane, Ethylene nature unsaturated-compound; cyclic ether compound; annular thioether compounds, such as an isobutylene and polybutadiene; a vinyl compound etc. can be mentioned.

[0054] These cationic polymerization nature monomers can also add one sort independently, or can also add it combining two or more sorts. the loadings (when using two or more sorts together, they are those total quantities) of these cationic polymerization nature monomer — sum total [of the compound (a) of this invention]: — the 100 mass sections — receiving — the 1 – 10,000 mass section — it is the 10 – 1,000 mass section preferably. Since hardenability will fall and energy required for hardening will increase if the compound with which only one has a cationic polymerization nature machine is added more than the 200 mass sections to the sum total:100 mass section of a compound (a) among the above-mentioned cationic polymerization nature monomers to intramolecular, it is not desirable.

[0055] In order to raise optical (activity energy line) hardenability to the constituent for optical waveguide resin of this invention, it is the range which does not check the purpose of this invention, and it is also possible to add a radical polymerization nature compound (d). As a compound (d), although there is especially no limitation, it can use the radical polymerization nature monomer of well-known common use of an acrylic ester (meta) system. Specifically Methyl (meta) acrylate, ethyl (meta) acrylate, n-propyl (meta) acrylate, n-butyl (meta) acrylate, 2-ethylhexyl (meta) acrylate, lauryl (meta) acrylate, Cyclohexyl (meta) acrylate, phenoxy ethyl (meta) acrylate, 2-ethoxyethyl (meta) acrylate, glycidyl (meta) acrylate, 2-hydroxyethyl (meta) acrylate, benzyl (meta) acrylate, Monofunctional (meta) acrylate compounds, such as ethylene glycol monochrome (meta) acrylate; Ethylene GURIKORUJI (meta) acrylate, Polyethylene GURIKORUJI (meta) acrylate, TORIMECHI roll pro pantry (meta) acrylate, Pentaerythritol tetrapod (meta) acrylate, dipentaerythritol PENTA (meta) acrylate, polyfunctional epoxy (meta)

acrylate resin, polyfunctional urethane (meta) acrylate resin, etc. can be mentioned.

[0056] Moreover, it is the purpose which adjusts the refractive index of the optical waveguide of this invention, and it is also possible to use the acrylate monomer which has a fluorine atom (meta) as a compound (d). Specifically, 2, 2, and 2-trifluoroethyl (meta) acrylate, 2, 2 and 3, 3-tetrafluoro propyl (meta) acrylate, pentafluoro propyl (meta) acrylate, hexafluoro isopropyl (meta) acrylate, octafluoropentyl (meta) acrylate, etc. can be mentioned.

[0057] the total 100 mass section of the cationic polymerization nature compound the compound (a) of this invention, a compound (b), a compound (c), and ****s other than these — receiving — the 5 – 200 mass section — it is the 10 – 100 mass section preferably. [the addition of a compound (d)] If an addition exceeds the 200 mass sections, set-to-touch nature will worsen. Moreover, since the rate of bridge formation of an acrylic (meta) radical increases in hardening, the thermal resistance of the obtained hardened material and chemical resistance fall.

[0058] In order to promote smoothly the radical polymerization of the above-mentioned radical polymerization nature compound (d), the thing of the well-known common use which it is desirable adding an optical radical initiator (e), it induces light, and generates a radical can be used. "Light" means radiations, such as a visible ray, ultraviolet rays, far ultraviolet rays, an X-ray, and an electron ray, here. As an optical radical initiator (e), for example A benzoin, benzoin ethyl ether, Benzoin iso-propyl ether, benzoin-n-butyl ether, Benzoin isobutyl ether, an acetophenone, a dimethylamino acetophenone, A 2 and 2-dimethoxy-2-phenyl acetophenone, 2, and 2-diethoxy-2-phenyl acetophenone, 2-hydroxy – 2-methyl-1-phenyl propane-1-ON, 1-hydroxy cyclohexyl phenyl ketone, 2-methyl – 1-[4-(methylthio) phenyl]-2-morpholino propane-1-ON (the product made from tiba speciality KEMIKARUZU; IRUGA cure 907), A 4-(2-hydroxy ethoxy) phenyl-2-(hydroxy-2-propyl) ketone, A benzophenone, p-phenylbenzo phenon, 4, and 4'-diethylamino benzophenone, A dichloro benzophenone, 2-methyl anthraquinone, 2-t-butyl anthraquinone, 2-aminoanthraquinone, 2-methylthio xanthone, 2-ethyl thioxan ton, 2-chloro thioxan ton, 2, 4-diethyl thioxan ton, benzyl dimethyl ketal, p-dimethylamine benzoate, 2 and 4, 6-trimethyl benzoyl diphenyl phosphine oxide (BASF A.G. make; RUSHIRIN TPO), Screw (2, 6-dimethoxybenzoyl) – 2, 4, and 4-TORIMECHIRU-pentyl phosphine oxide content initiator (the product made from tiba speciality KEMIKARUZU; IRUGA cures 1700, 149, and 1800), Bis(2, 4, 6-trimethyl benzoyl)-phenyl phosphine oxide (the product made from tiba speciality KEMIKARUZU; IRUGA cure 819) etc. is mentioned. These can be used as one sort or two sorts or more of mixture.

[0059] 0.007–0.5 mols can be used for the amount of the optical radical initiator (e) used to 1Eq of radical polymerization nature functional groups, such as an acrylic (meta) radical of the radical polymerization nature compound in a constituent (d).

[0060] An ion trap agent can be included in the constituent for optical waveguide resin of this invention if needed. An ion trap agent can be changed to the matter which reacts with the impurity which consists of an anion or a cation, and is defanged.

[0061] The constituent for optical waveguide resin of this invention may contain aliphatic series polyol further. This aliphatic series polyol gives flexibility to the optical waveguide resin of this invention, or gives effectiveness, such as raising the integration of a reaction in room temperature aging after a hardening reaction. As aliphatic series polyol, a glycerol besides alkylene glycol (Pori), such as ethylene glycol, propylene glycol, a polyethylene glycol, a polypropylene glycol, and a butylene glycol, polyglycerin, pentaerythritol, the poly caprolactone polyol, etc. are mentioned, for example. the loadings — per total 100 mass section of component [in the constituent for optical waveguide resin of this invention] (a) – (e), and other cationic polymerization nature monomer components, and 5 – 50 mass section — you may be 10 – 30 mass section extent preferably.

[0062] A sensitizer can also be used in order to raise a rate of polymerization, in case polymerization hardening of the constituent for optical waveguide resin of this invention is carried out by the ultraviolet rays which are one of the activity energy lines. As a sensitizer used for such the purpose, a pyrene, perylene, 2, 4-diethyl thioxan ton, 2, 4-dimethyl thioxan ton, 2, 4-dichloro thioxan ton, phenothiazin, etc. are mentioned. The amount of [in the case used of using a sensitizer together] has the desirable range of the 0.1 – 100 mass section to the photo-

oxide type-of-seasonal-prevalence cationic initiator 100 mass section.

[0063] furthermore, the additives of well-known common use like stress relaxation agents, such as flame retarders, such as a nitrogen-containing compound, silicone oil, and silicone rubber powder, including adhesion grant agents by the Shin-etsu silicone company, such as defoaming agent; leveling agent; imidazole systems, such as a silicone system, a fluorine system, and a giant-molecule system, a thiazole system, a triazole system, and a silane coupling agent, for example, a silane coupling agent, KBM303 and KBM403, a KBM402; antimony trioxide, phosphoric ester, red phosphorus, and melamine resin can be used if needed.

[0064] The constituent for optical waveguide resin of this invention can be obtained by mixing constituents, such as a compound (a) described so far, a compound (b), and a compound (c), with the mixed equipment of well-known common use of the agitator by the wing, a stirring kneading machine, a paint shaker, a kneader, 3 roll mills, etc. Although there will be especially no limitation if mixed equipment is equipment which can mix each constituent to homogeneity, it is necessary to select in consideration of the viscosity of a constituent etc.

[0065] The polymerization (hardening) of the constituent for optical waveguide resin in this invention can be carried out with an exposure and/or heating of an activity energy line. An activity energy line here shows ultraviolet rays, an X-ray, an electron ray, a gamma ray, etc. As the light source in the case of irradiating ultraviolet rays, a metal halide lamp, a mercury arc lamp, a xenon arc lamp, a fluorescent lamp, a carbon arc lamp, a tungsten-halogen copy lamp, sunlight, etc. can be mentioned.

[0066] the case where the constituent for optical waveguide resin of this invention is stiffened with heating — heating conditions — desirable — about 50–250 degrees C — more — desirable — about 75–200 degrees C — setting — about 0.2 – 60 minutes — desirable — about 0.5— it is more preferably good as conditions for about 1 – 10 minutes for 20 minutes.

[0067] As for the refractive index of the optical waveguide of this invention, it is desirable that it is 1.40–1.70 to the D line of the sodium in 25 degrees C, and the core section or the clad section of optical waveguide is formed in this range. Therefore, it is desirable for the refractive indexes of the constituent for optical waveguide resin to be also 1.40–1.70. The core section and the clad section which constitute optical waveguide can form the optical waveguide which the refractive-index difference of the core section and the clad section excelled in the optical propagation property about by 1.5 in the case of the single mode when the refractive index was about [0.01 to 0.1 or more] in the case of about [0.001 or more] and a multimode.

[0068] Generally, the constituents for optical waveguide resin are mixture, such as an oxetane compound and an epoxy compound, as described until now. As for these oxetane compound and an epoxy compound, it is possible for a refractive index to control the refractive index of optical waveguide resin to arbitration by changing to be 1.40 to about 1.70 and to choose these compounds appropriately and a compounding ratio.

[0069] Next, an example of the manufacture approach of optical waveguide using the constituent for optical waveguide resin is explained with reference to drawing 1.

[0070] First, as shown in drawing 1 (A), on the substrate 10 which consists of silicon, it applies so that the thickness after hardening the constituent for the optical waveguide clad sections may be set to about 30 micrometers, and constituent layer 11a for the clad sections is formed.

[0071] Next, as shown in drawing 1 (B), the constituent for the optical waveguide clad sections is stiffened to constituent layer 11a for the clad sections using an extra-high pressure mercury lamp by irradiating ultraviolet rays for 60 seconds with the output of 25 mW/cm² on the whole surface. Thereby, as shown in drawing 1 (C), the clad section 11 of optical waveguide is formed. In addition, if constituent layer 11a is stiffened completely, a refractive index will become large about 0.025, for example. When hardening the clad section, the approach by photo-curing is possible, and heat curing which used the heat cation curing agent in complete hardening is also possible.

[0072] Next, as shown in drawing 1 (D), on the clad section 11, it applies so that the thickness after hardening the constituent for the optical waveguide core sections may be set to about 30 micrometers, and constituent layer 12a is formed.

[0073] Furthermore, ultraviolet rays are irradiated to constituent layer 12a through the photo

mask 21 which has stripe-like opening. Alignment is carried out, a photo mask 21 is specifically arranged so that constituent layer 12a for the core sections may not be contacted on constituent layer 12a for the core sections, and ultraviolet rays are irradiated towards constituent layer 12a from a photo-mask 21 side. The exposure of ultraviolet rays is performed for 5 – 120 seconds with the output of 20 – 200 mW/cm² using an extra-high pressure mercury lamp. Thereby, as shown in drawing 1 (E), in the part 12a1 corresponding to opening of the photo mask 21 of constituent layer 12a for the core sections, the constituent for the optical waveguide core sections hardens.

[0074] As mentioned above, it is necessary to arrange a photo mask 21, in order for constituent layer 12a for the core sections and a photo mask 21 to paste up, if ultraviolet rays are irradiated after non-hardened constituent layer 12a for the core sections and a photo mask 21 have stuck here so that constituent layer 12a for the core sections may not be contacted. There are a pro squeak tee exposing method exposed by preparing the gap of about 100 micrometers between a mask and the exposed body as such an approach, the projection exposing method which is made to estrange a mask and the exposed body and is exposed by carrying out image formation optically.

[0075] After irradiating ultraviolet rays and predetermined time amount passes, ultraviolet rays are not irradiated with a photo mask 21, but dissolution removal of the part 12a2 in the condition of not hardening is carried out with developers, such as an acetone. Since the crosslinking density of the part 12a1 which the clad section 11 and core section constituent layer 12a hardened is high at this time, there is little possibility that these fields will dissolve.

[0076] Next, hardened material layer 12a is washed using isopropyl alcohol as a rinse, and the acetone which permeates the interior of hardened material layer 12a, and is made to swell hardened material layer 12a is removed. Thereby, as shown in drawing 1 (F), a flat-surface configuration is beltlike and the core section 12 of two or more optical waveguides whose refractive indexes are about 1.56 is formed.

[0077] Finally, as shown in drawing 1 (G), using the ingredient same on the exposure of the clad section 11, and the core section 12 as the clad section 11, by the same approach as the clad section 11, the clad section 13 is formed and the optical waveguide of the embedding mold which consists of the core section 12 and the clad sections 11 and 13 is completed.

[0078] Thus, in the manufactured optical waveguide, if a lightwave signal carries out incidence to an end side, this lightwave signal will spread the interior and it will carry out outgoing radiation from an other end side.

[0079] As for the developer used in the manufacture approach of the optical waveguide in this invention, it is desirable that the effect which is excellent in the solubility over the part in the condition of not hardening, i.e., the solubility over the constituent for optical waveguide resin, and it has on the hardened part uses few solvents. As such a solvent, ethyl acetate, butyl acetate, gamma-butyrolactone, Ester, such as ethylene glycol monoethyl ether acetate and propylene-glycol-monomethyl-ether acetate; Ethylene glycol monoethyl ether, Diethylene glycol monoethyl ether, propylene glycol monomethyl ether, Ether alcohol, such as dipropylene glycol monomethyl ether; An acetone, The ether, such as ketone; dioxanes, such as a methyl-ethyl ketone and methyl isobutyl ketone, and a tetrahydrofuran; aromatic hydrocarbon, such as benzene, toluene, and a xylene, etc. is mentioned. These may be used by one sort, and may mix and use two or more sorts. Moreover, the solvent with low solubility of the constituent for optical waveguide resin, for example, water, alcohol, etc., may be added to these solvents, and the bloating tendency of a hardened material may be adjusted to them. Among these solvents, since toxicity is low and the boiling point is also low, the acetone also has the advantage of being easy to deal with it generally, and is desirable.

[0080] Since the hardened core section is hardly invaded but it is easy to dissolve it with a developer, while using isopropyl alcohol as a rinse used in the manufacture approach of the optical waveguide in this invention can remove a part for a non-hard spot completely, it is because it can finish without leaving the hardened core part in a nearly perfect form, and leaving dust to a substrate top face.

[0081] As a rinse used for such the purpose, although it changes also with classes of developer,

lower alcohol, such as a methanol, ethanol, isopropyl alcohol, and a butanol, is desirable. Furthermore, it is isopropyl alcohol preferably.

[Translation done.]

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EXAMPLE

[Example] Although an example is given and this invention is hereafter explained further to a detail, this invention is not limited to these examples at all. In addition, the "section" in an example and the example of a comparison is the mass section as long as there is no notice especially.

[0083] In addition, among the ingredients used in the example and the example of a comparison, the commercial item was as follows, and it was used as it was, without refining.

POX: The Toagosei make, 3-ethyl-3-phenoxyethyl oxetane XDO : The Toagosei make, 1 and 4-bis[(3-ethyl-3-OKISETA nil methoxy) methyl] benzene 3000 : The Daicel Chemical Industries, Ltd. make (trade name SEROKI side 3000), Limonene dioxide 2110 : The Asahi Denka Kogyo make (trade name KRM-2110), 2 organic-functions cycloaliphatic epoxy resin 828 : Oil-ized shell epoxy company make (trade name Epicoat 828), Bisphenol A mold epoxy resin M-309:Toagosei make and trimethylolpropane triacrylate 3000A : Epoxy ester by Kyoeisha chemistry company 3000A, Bisphenol A diglycidyl-ether acrylic-acid addition-product SI-60L: 3 Japanese Federation of Chemical Industry Workers' Unions industrial company make (trade name SAN-AID SI-60L), a heat cationic initiator (sulfonium salt)

6990: Made in Union Carbide (trade name UVI-6990), the optical cationic initiator 907 : the Ciba Specialty Chemicals make (trade name IRUGA cure 907), a photopolymerization initiator [0084] That to which the artificer did chemosynthesis of the compound which is not marketed was used. That is, about the 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane and 6, and 7-epoxy-2-oxaspiro [3.5] nonane, this invention person compounded the approach given in a U.S. Pat. No. 3388105 number to reference. In detail, the 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane was compounded as follows.

[0085] 2-methyl-4-cyclohexene-1-carboaldehyde 327g which is the Diels-Alder resultant of a butadiene and a crotonaldehyde, methanol 600ml, and 729g of 37% of formalin water are fed into a <composition of 6-methyl-3-cyclohexene -1 and 1-dimethanol> 3 opening flask, and the temperature up was carried out to 60 degrees C, stirring this solution. Then, the solution which dissolved KOH252g in 600ml of distilled water was dropped over 2 hours. After continuing stirring for 7 hours, vacuum concentration of the reaction solution was carried out, and the residue of a bilayer was obtained. 300ml distilled water washed the oil reservoir condensed by about 150ml. After carrying out vacuum concentration of the oil reservoir, 50mg (BHT) of 3 and 5-JI (t-butyl)-4-hydroxytoluene was added, vacuum distillation was performed, and 6-methyl-3-cyclohexene -1 and 1-dimethanol 311g (82% of yield) which is a colorless crystal was obtained.

[0086] 6-methyl-3-cyclohexene -1 and 1-dimethanol 310g (1.99 mol), dimethyl carbonate (DMC) 894g, and 0.93g of potassium carbonate were taught to the <composition of 6-methyl-3-cyclohexene -1 and 1-dimethanol annular carbonate> 3 opening flask, the temperature up was carried out to 90 degrees C, and it was made to flow back for 4 hours. The reaction solution was returned to the room temperature and potassium carbonate was carried out the ** exception. After adding 120mg of BHT(s), DMC and the methanol which remain were removed under reduced pressure of 2kPa(s) (15mmHg), vacuum distillation was performed continuously, and 326g (89.4% of yield) of the 6-methyl-3-cyclohexenes -1 and 1-dimethanol annular carbonates which are an ordinary temperature colorlessness crystal were obtained.

[0087] The 6-methyl-3-cyclohexene -1, 321.15g of 1-dimethanol annular carbonates, BHT642mg (0.2 mass %), and LiCl1.93g were taught to the <composition of 9-methyl-2-oxaspiro [3.5] nona-6-en (CHEO)> 3 opening flask, and heating stirring was carried out at 275 degrees C using the mantle heater. Heating was continued for 4 hours until it stopped having extracted and distilled the product immediately the bottom of reduced pressure of about 8 kPa(s) (60mmHg), and out of the system. BHT600mg was added to the product, vacuum distillation was performed and 187g (71% of yield) of CHEO(s) which are a transparent and colorless liquid was obtained.

[0088] Since <composition of 7 and 8-epoxy-5-methyl-2-oxaspiro [3.5] nonane (ECHO)> CHEO50g was dissolved in 150ml dichloromethane, it supplied to the reactor. The thing which made 400ml dichloromethane suspend 93.7g of m-chloro perbenzoic acids was dropped over 1 hour so that a reaction solution might not exceed 40 degrees C. Depositing m-chloro benzoic acid was carried out the ** exception, and was often washed by cold dichloromethane. 15.0g of calcium hydroxides was thrown into the organic layer, the depositing crystal was carried out the ** exception after 30-minute stirring, and it washed by cold dichloromethane. It condensed, after 5% of NaHSO4 water and saturation brine washed the organic layer, and 38.1g (73.7% of yield) of ECHO(s) of a colorless semisolid configuration was obtained in ordinary temperature by vacuum distillation.

[0089] The 6-ethyl-3-cyclohexene-1-carboaldehyde which is the Diels-Alder resultant of a butadiene and trans-2-pen TENARU was used instead of the Diels-Alder resultant of the butadiene and crotonaldehyde which were used by composition of the <composition of a 7 and 8-epoxy-5-ethyl-2-oxaspiro [3.5] nonane (EECHO)> ECHO, and this invention person compounded with the procedure similar to the above.

[0090] instead of [of the Diels-Alder resultant of the butadiene and crotonaldehyde which were used by composition of the <composition of a 7 and 8-epoxy-5-trifluoromethyl-2-oxaspiro [3.5] nonane (EFCHO)> ECHO] — a butadiene and trans- the Diels-Alder resultant with a 4, 4, and 4-trifluoro-2-buthenal was used, and this invention person compounded with the procedure similar to the above.

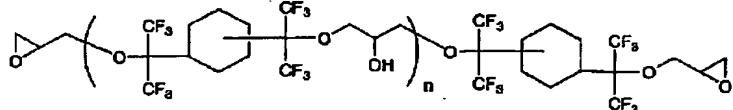
[0091] 5% palladium / activated carbon is made into a catalyst for the aforementioned 6-methyl-3-cyclohexene -1 and 1-dimethanol in toluene at a <composition of 5-methyl-2-oxaspiro [3.5] nonane (CHO)> 1L3 opening flask. 2-methylcyclohexane [which carried out hydrogenation / which was obtained with hydrogen gas] -1, and 1-dimethanol 474g, 405g of dimethyl carbonate, and 1.4g of potassium carbonate were put in, and it reacted for 14 hours, distilling off the methanol which carries out heating stirring and which is generated at the temperature of 100 degrees C among an oil bath out of a system by ordinary pressure. Finally the inside of a reaction container was made reduced pressure to 10mmHg(s), and the corresponding carbonate was obtained at 95% of yield.

[0092] It reacted for 10 hours, having carried out heating stirring of the obtained annular carbonate at 250 degrees C as it was, and discharging the produced carbon dioxide gas out of a system from the upper part of a cooling system. Distillation purification of this reaction solution was carried out, and CHO230g was obtained.

[0093] The 2-phenylcyclohexane -1 and 1-dimethanol which are obtained by carrying out hydrogenation of the Diels-Alder resultant of a butadiene and trans-cinnamaldehyde with hydrogen gas instead of the 2-methylcyclohexane -1 used by composition of <composition of 2-OKISA-5-phenyl SUPIRO [3.5] nonane (PCHO)> CHO and 1-dimethanol by making 5% palladium / activated carbon into a catalyst in toluene were used, and this invention person compounded with the same procedure as the above.

[0094] Instead of the 6-methyl-3-cyclohexene -1 obtained from the Diels-Alder reactant of a butadiene and a crotonaldehyde used at the time of <composition of spiro [bicyclo [2.2.1] heptane -2 and 3'-oxetane] (NRBO)> CHO composition, and 1-dimethanol 5% palladium / activated carbon is made into a catalyst for a cyclopentadiene, the bicyclo [2.2.1] hepta-5-en -1 which is the resultant of an acrolein, and 1-dimethanol in toluene. With hydrogen gas this invention person compounded with the same procedure as the above by completely performing the same reaction using the bicyclo [2.2.1] heptane -1 and 1-dimethanol which carried out hydrogenation.

[0095] <Composition (fluorination epoxy resin A) which is diglycidyl ether which is a bis(1, 1, 1, 3, 3, and 3-hexafluoro isopropyl) cyclohexane> [Formula 12]



Macromolecules It compounded according to 1996, 29, and 2006-2010. Obtained fluorination epoxy resin A used the mixture of 15% of things whose things of 0 are [n of a repeat unit] 1, 85% of things which are 3, and 1 and 4 for association of 100% and a cyclohexane.

[0096] <Examples 1-8 and the examples 1-3 of a comparison> — the photoresist of the constituent for optical waveguide resin was examined first. The oxetane compound, the epoxy compound, the optical cationic initiator, etc. were mixed by the combination (the numeric value of front Naka is the mass section) shown in Table 1, and each constituent for optical waveguide resin was obtained.

[0097] Thus, about each obtained constituent for optical waveguide resin, as it was the following, the photo-curing sex test was performed. On the glass substrate, the thickness of a constituent layer was applied so that it might be set to 100 micrometers. Then, it irradiated for 10 seconds with the output of 24 mW/cm² using the metal halide lamp, and the constituent layer was hardened. The condition of the tuck of the hardened constituent layer is investigated by the fingertip, and the obtained result is shown in Table 1. Here, when there was no tuck in a hardened material layer, there was a tuck a little and “**” and a tuck existed [“O” and], it was described as “x.”

[0098] Although it is the mixture of an alicyclic compound (a) and an epoxy compound which has the OKISETANIRU radical of this invention, as for examples 1-8, it turns out that it excels in hardenability.

[0099] On the other hand, although the example 1 of a comparison was the constituent of only an epoxy compound, it did not harden at all but the remarkable tuck was shown. Moreover, the examples 2 and 3 of a comparison are examples using the oxetane compound which does not have alicyclic structure as an oxetane compound. Although the improvement in hardenability was checked compared with the constituent of only an epoxy compound, as compared with the example which mixed the alicyclic compound (a) which has the OKISETANIRU radical of this invention, hardenability was a little inferior. To the oxetane compound of this invention, although the example 4 was a mixed example of other oxetane compounds, it was hardened enough. The hardenability of the alicyclic compound (a) which has the OKISETANIRU radical of this invention is reflected. Moreover, in the example 5, although it was the example which mixed the radical polymerization initiator with the radical polymerization nature compound, this example was also hardened enough.

[0100] Thus, it turns out that the constituent for optical waveguide resin containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention is excellent in hardenability.

[0101] Furthermore, about the thing after full hardening of each obtained constituent for optical waveguide resin (light was irradiated further and it was made to harden completely), the refractive index to the D line of the sodium in 25 degrees C was measured, and the result was shown in Table 1. The refractive index was measured with the Abbe refractive-index plan (Atago Co., Ltd. Abbe refractive-index total 1 mold). As for the refractive index, it turned out that it can change with 1.465 to 1.550 and can adjust as a constituent for the object for the clad sections, and the core sections.

[0102]

[Table 1]

		実施例								比較例		
	化合物	1	2	3	4	5	6	7	8	1	2	3
オキセタン化合物(a)	CHO	20										
	CHEO		30									
	PCHO									10		
	NRBO					10						
	ECHO			50	50	40	30	25				
	EECHO							25				
	EFCHO								10			
その他のオキセタン化合物	POX										30	
	XDO				10					10		50
エポキシ化合物	セロキサイド3000									10		
	KRM-2110	50	40				30			30	80	40
	エピコート828	30	30	50	40		20	50		10	30	50
	フッ素化エポキシ樹脂A					50			40			
ラジカル重合性化合物	M-309						5					
	3000A						15					
光カチオン重合開始剤	UVI-6990	3	3	3	3	3	3	3	3	3	3	3
光ラジカル開始剤	イルガキュ7907						1					
光硬化性	○	○	○	○	○	○	○	○	○	x	△	△
硬化後の屈折率	1.532	1.531	1.547	1.505	1.465	1.498	1.550	1.480	1.523	1.571	1.569	

[0103] The thermosetting of the constituent examples 9-11 and for <examples 4-6 of comparison> optical waveguide resin was examined. Each constituent for optical waveguide resin was similarly adjusted except having changed the optical cationic initiator of examples 1-8 and the examples 1-3 of a comparison into heat cationic initiator SI-60L. The (mass section) is shown for loadings in Table 2.

[0104] Thus, about each obtained constituent for optical waveguide resin, as it was the following, the heat-curing sex test was performed. The class product was put in into the sample bottle and it soaked in the 80-degree C oil bath. Thermosetting was judged as follows about the description of the class product after hardening for 1 minute. It is [“**” and the thing of “x” and the thing currently thickened which is carrying out full hardening] “O which viscosity has hardly changed and carried out.”

[0105] The result was shown in Table 2. Thermosetting is [constituent / containing the alicyclic compound (a) which has the OKISETANIRU radical of this invention / an epoxy compound independent or other oxetane compounds] remarkably high.

[0106] Although heat curing could also be used if needed in the clad section of optical waveguide, it turned out that the constituent for optical waveguide resin of this invention has sufficient hardenability also in heat curing.

[0107]

[Table 2]

		実施例				比較例		
	化合物	9	10	11	4	5	6	
オキセタン化合物(a)	CHO	20						
	CHEO		30					
	ECHO			50				
その他のオキセタン化合物	POX					30		
	XDO						50	
エポキシ化合物	セロキサイド3000				10			
	KRM-2110	50	40		80	40		
	エピコート828	30	30	50	10	30	50	
	SI-60L	3	3	3	3	3	3	
熱硬化性	○～△	○～△	○	x	△	△		

[0108] Example of manufacture and constituent ECHO for the clad sections of <example 12> optical waveguide 40 mass sections, 2110 Ten mass sections, 828 Ten mass sections, optical cationic initiator UVI-6990 Three mass sections were mixed so that it might become homogeneity enough. Furthermore, the constituent for the optical waveguide clad sections was obtained by filtering and removing dust etc. In addition, the thing of the same name of article as what was stated in the examples 1-8 was used for each ingredient.

[0109] – Constituent ECHO for the core sections 30 mass sections, 2110 Ten mass sections, 828 60 mass sections, optical cationic initiator UVI-6990 Three mass sections were mixed so that it might become homogeneity enough. Furthermore, the constituent for the optical

waveguide core sections was obtained by filtering and removing dust etc. In addition, the thing of the same name of article as what was stated in the examples 1–8 was used for each ingredient.

[0110] Next, manufacture of optical waveguide is explained. As shown in drawing 1 (A), the substrate 10 which consists of silicon was prepared and constituent layer 11a which consists of a constituent for the optical waveguide clad sections was formed with the spin coat method the whole surface on this substrate 10. Then, as shown in drawing 1 (B), the ultraviolet rays of 2500 mJ/cm² were irradiated using the extra-high pressure mercury lamp to constituent layer 11a. The clad section 11 was formed by hardening constituent layer 11a (drawing 1 (C)). At this time, the thickness of the clad section 11 was 30 micrometers. Moreover, it was 1.512 when the refractive index of the clad section 11 to the D line of the sodium in 25 degrees C was measured.

[0111] Next, as shown in drawing 1 (D), on the clad section 11, the spin coat method was used and constituent layer 12a was formed by applying the constituent for the optical waveguide core sections.

[0112] Furthermore, it has arranged so that 100 micrometers of photo masks 21 which have opening of the shape of a stripe whose width of face is 30 micrometers may be estranged from the front face of a substrate 10, and the ultraviolet rays of 1500 mJ/cm² were irradiated to constituent layer 12a through this photo mask 21 using the extra-high pressure mercury lamp (the pro squeak tee exposing method). Part 12a1 corresponding to [as this showed drawing 1 (E)] opening of the photo mask of constituent layer 12a The constituent for the optical waveguide core sections which constitutes constituent layer 12a then hardened. At this time, the thickness of hardened constituent layer 12a was 30 micrometers. Moreover, when the refractive index to the D line of the sodium in 25 degrees C was measured, it was 1.558, and the refractive-index difference with the clad section 11 was 0.046.

[0113] After irradiating ultraviolet rays, ultraviolet rays are not irradiated with a photo mask 21, but it is the part 12a2 in the condition of not hardening. Dissolution removal was carried out with the acetone. Then, hardened material layer 12a (12a1) was washed using isopropyl alcohol. Thus, as shown in drawing 1 (F), two or more core sections 12 with a beltlike flat-surface configuration were formed.

[0114] Finally, as shown in drawing 1 (G), the clad section 13 was formed by the same approach as the clad section 11 on the exposure of the clad section 11, and the core section 12 using the same constituent as the clad section 11, and the optical waveguide of an embedding mold was produced.

[0115] <Example 13> width of face produced optical waveguide like the example 12 except for having formed the core section with a width of face of 50 micrometers using the photo mask 21 (refer to drawing 1 (D)) which has opening of the shape of a stripe which is 50 micrometers.

[0116] <Example 14> width of face produced optical waveguide like the example 12 except for having formed the core section with a width of face of 70 micrometers using the photo mask 21 which has opening of the shape of a stripe which is 70 micrometers.

[0117] Thus, about the optical waveguide of the acquired examples 12–14, the trial about optical transmission loss was performed, respectively. This trial used the wavelength of 790nm, and 650nm semiconductor laser, and measured the propagation loss in TE (Transverse Electro) mode and TM (Transverse Magnetic) mode by the cutting-back method (how to measure the output power of optical waveguide, while cutting optical waveguide short gradually). The obtained result is shown in Table 3.

[0118] In addition, the TE mode is the mode in which an electric-field component exists only in the cross section of optical waveguide, and it has a field component in the optical propagation direction. Moreover, the TM mode is the mode in which a field component exists only in the cross section of optical waveguide, and it has an electric-field component in the optical propagation direction.

[0119] As shown also in Table 3, also in which the mode of the TE mode and the TM mode, the small value of 0.22–0.37dB/cm was acquired, and the optical waveguide of examples 12–14 was a good thing which has few optical transmission loss.

[0120]

[Table 3]

測定波長 (nm)	伝搬モード	光伝搬損失(dB/cm)		
		実施例12	実施例13	実施例14
790	TEモード	0.26	0.25	0.23
	TMモード	0.25	0.23	0.22
650	TEモード	0.35	0.37	0.34
	TMモード	0.34	0.35	0.33

[Translation done.]

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing an example of the production process of the optical waveguide using the constituent for optical waveguide resin of this invention.

[0124]

[Description of Notations]

11a The constituent layer for optical waveguide resin for the clad sections

10 Substrate

11 Clad Section (Hardened Material of Constituent for Optical Waveguide Resin for Clads)

21 Photo Mask

12a The constituent layer for section optical waveguide resin for cores

Twelvea1 Hardened material of the constituent for optical waveguide resin for the core sections

Twelvea2 Non-hardened material of the constituent for optical waveguide resin for the core sections

12 Core Section

13 Clad Section

[Translation done.]

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DRAWINGS

[Drawing 1]

(A)



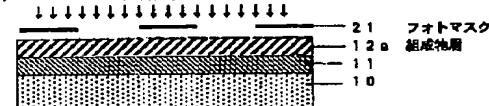
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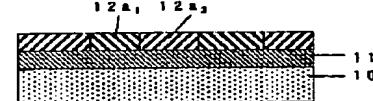
(C)



(D)



(E)



(F)



(G)



[Translation done.]

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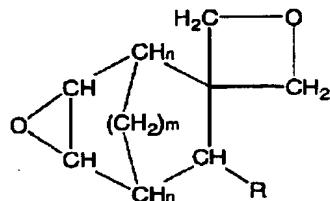
(54)【発明の名称】光導波路樹脂用組成物

(57)【要約】

【課題】活性エネルギー線の照射および/または加熱により高い活性(速重合性、速硬化性)を示し、屈折率を自由に調製し得る光導波路樹脂用組成物を提供すること。

【解決手段】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)と活性エネルギー線の照射および/または加熱によりカチオン重合を開始させる化合物(b)を含む光導波路樹脂用組成物。

【化1】



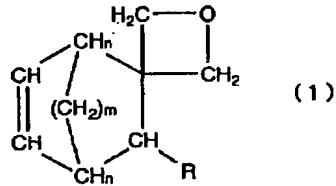
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【特許請求の範囲】

【請求項1】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)を含むことを特徴とする光導波路樹脂用組成物。

【請求項2】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)が一般式(1)で表される化合物であることを特徴とする請求項1に記載の光導波路樹脂用組成物。

【化1】

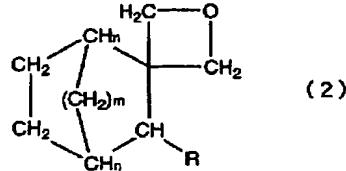


(式中Rは水素原子、または炭素数1～12のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、mは0～2の整数で、nはmが0の場合は2、それ以外は1である。)

【請求項3】一般式(1)で示される化合物が2-オキサスピロ[3.5]ノナー-6-エンまたは5-メチル-2-オキサスピロ[3.5]ノナー-6-エンであることを特徴とする請求項2に記載の光導波路樹脂用組成物。

【請求項4】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)が一般式(2)で表される化合物であることを特徴とする請求項1に記載の光導波路樹脂用組成物。

【化2】



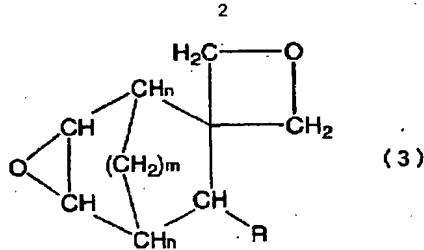
(式中Rは水素原子、または炭素数1～12のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、mは0～2の整数で、nはmが0の場合は2、それ以外は1である。)

【請求項5】一般式(2)で示される化合物が2-オキサスピロ[3.5]ノナンまたは5-メチル-2-オキサスピロ[3.5]ノナンであることを特徴とする請求項4に記載の光導波路樹脂用組成物。

【請求項6】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)が一般式(3)で表される化合物であることを特徴とする請求項1に記載の光導波路樹脂用組成物。

【化3】

2



(式中Rは水素原子、または炭素数1～12のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、mは0～2の整数で、nはmが0の場合は2、それ以外は1である。)

【請求項7】一般式(3)で示される化合物が7,8-エポキシ-5-メチル-2-オキサスピロ[3.5]ノナン、6,7-エポキシ-2-オキサスピロ[3.5]ノナンであることを特徴とする請求項6に記載の光導波路樹脂用組成物。

【請求項8】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)が一般式(1)、一般式(2)および一般式(3)で表される化合物から選択された少なくとも一種であることを特徴とする請求項1に記載の光導波路樹脂用組成物。

【請求項9】一個以上のエポキシ基を有し、オキセタニル基を有しない化合物(b)を含有することを特徴とする請求項1～8のいずれか一つに記載の光導波路樹脂用組成物。

【請求項10】一個以上のエポキシ基を有し、オキセタニル基を有しない化合物(b)がフッ素原子を有することを特徴とする請求項9に記載の光導波路樹脂用組成物。

【請求項11】活性エネルギー線の照射および／または加熱によりカチオン重合を開始させる化合物(c)を含むことを特徴とする請求項1～10のいずれか一つに記載の光導波路樹脂用組成物。

【請求項12】活性エネルギー線の照射および／または加熱によりカチオン重合を開始させる化合物(c)がスルホニウム塩、ヨードニウム塩、ホスホニウム塩およびジアゾニウム塩の中から選ばれた1種以上である請求項11に記載の光導波路樹脂用組成物。

【請求項13】ラジカル重合性化合物(d)を含むことを特徴とする請求項1～12のいずれか一つに記載の光導波路樹脂用組成物。

【請求項14】光ラジカル開始剤(e)を含むことを特徴とする請求項1～13のいずれか一つに記載の光導波路樹脂用組成物。

【請求項15】硬化物の25℃におけるナトリウムのD線に対する屈折率が、1.40以上1.70以下の範囲内の値であることを特徴とする請求項1～14のいずれか一つに記載の光導波路樹脂用組成物。

【請求項16】請求項1～15のいずれか一つに記載の光導波路樹脂用組成物を硬化させて得られた光導波路。

【請求項17】コア部およびクラッド部を有すると共に、コア部またはクラッド部の少なくとも一方が請求項1～15のいずれか一つに記載の光導波路樹脂用組成物を硬化して得られたものであることを特徴とする光導波路。

【請求項18】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)と活性エネルギー線の照射および/または加熱によりカチオン重合を開始させる化合物(c)を含む光導波路樹脂用組成物を用いた層に活性エネルギー線を選択的に照射することにより、当該組成物を選択的に硬化させ、未硬化部分を除去する現像処理により光導波路を形成する光導波路の製造方法。

【請求項19】請求項16に記載の光導波路が使用された光デバイス。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、内部を光信号が伝搬し得る光導波路を形成するための硬化性組成物、及びその組成物を硬化して得られた光導波路、並びにその光導波路を用いた光関連材料に関する。

【0002】

【従来の技術】IC(Integrated circuit;集積回路)やLSI(Large Scale Integration;大規模集積回路)における技術の進歩により、それらの動作速度や集積規模が向上し、マイクロプロセッサの高性能化やメモリチップの大容量化が急速に達成されている。従来、機器内のボード間、あるいはボード内のチップ間など比較的短距離間の情報伝達は、主に、電気信号により行われてきた。今後、集積回路の性能を更に向上させるためには、信号のさらなる高速化や信号配線の高密度化が必要となるが、電気信号配線においては、それら高速化および高密度化が限界に達しつつあると共に、配線のCR(C:配線の静電容量、R:配線の抵抗)時定数による信号遅延が問題となっている。また、電気信号の高速化や電気信号配線の高密度化は、EMI(Electromagnetic Interference)ノイズの原因となるため、その対策も不可欠となる。

【0003】そこで、これらの問題を解消するものとして、光配線(光インターフェクション)が注目されている。光配線は、機器間、機器内のボード間、あるいはボード内のチップ間など種々の箇所に適用可能であると考えられている。中でも、チップ間のような短距離間の信号の伝送には、チップが搭載されている基板上に光導波路を形成し、これを伝送路とした光伝送・通信システムを構築することが好適であると考えられる。

【0004】ここで用いられる導波路は光配線以外に、光学部品分野に用いられる光スイッチ、光コネクター、光分波合波器、光分波結合器、光減衰器、光アイソレータ等の光受動部品や光回路部品などの光デバイスに使用できる。これら光デバイスに関しては「透明プラスチッ

クの最新市場」シーエムシー出版1999年刊行、p.161～175に記載がある。以下、光関連材料に用いられる導波路に関するもの全てを光導波路として総括して記載する。

【0005】従来、この種の光導波路としては、石英などの無機ガラスが用いられていた。しかしながら、無機ガラスを用いて光導波路を形成する場合には、高温による熱処理を行う必要があるため、半導体基板やプラスチック基板等の高温下において熱処理を行うことが困難な基板上に、光導波路を形成することはできなかった。

【0006】一方、近年、高分子材料を用いた光導波路が提案され、実用化されつつある。高分子材料は、無機材料と比較して加工が容易であり、大面積化やフィルム化を容易に行うことができる。また、フレキシブルであるため用途が広いこと、屈折率の調整が容易であること等の種々の利点を有する。中でも、紫外線硬化型の樹脂は、大量生産を行うことが可能な材料であるために、光導波路用の材料として期待されている。このような紫外線硬化型の樹脂としては、エポキシ樹脂が広く知られている。

【0007】エポキシ樹脂を用いた光導波路は、一般に、支持基材上に樹脂を塗布し、樹脂を選択露光したのち、樹脂の未硬化部分をウェットエッティングする現像処理を行うことにより形成される。

【0008】しかしながら、エポキシ樹脂の重合性は低いため、エポキシ樹脂を用いて光導波路を形成する場合には、樹脂を硬化させる際に多量のエネルギーが必要であり、生産効率が悪くなってしまうという問題があった。

【0009】一方、オキセタン化合物はエポキシ化合物と混合することによりカチオン硬化が著しく向上することが知られている。このようなことから特開2000-356720号公報ではこれらオキセタン化合物を用いた光導波路樹脂用組成物が示されているが実際に光導波路に用いるために十分な硬化速度を有しているとは言えないのが現状である。

【0010】

【発明が解決しようとする課題】本発明はかかる問題点に鑑みてなされたものであり、重合性に優れた光導波路樹脂用組成物、並びにそれを用いた光導波路およびその製造方法を提供することにある。

【0011】

【課題を解決するための手段】本発明者らは、上記課題の解決について鋭意検討した結果、特定のカチオン重合性化合物と、活性エネルギー線の照射および/または加熱によりカチオン重合を開始させる化合物とを含む光導波路樹脂用組成物が前記課題を解決できることを見出し、本発明を完成するに至った。

【0012】すなわち、本発明は以下の[1]～[19]に示される光導波路樹脂用組成物、並びにそれを用

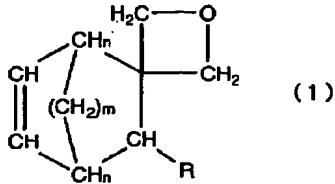
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いた光導波路およびその製造方法に関する。

【0013】 [1] 分子内に少なくとも一個のオキセタニル基を有する脂環式化合物 (a) を含むことを特徴とする光導波路樹脂用組成物。

【0014】 [2] 分子内に少なくとも一個のオキセタニル基を有する脂環式化合物 (a) が一般式 (1) で表される化合物であることを特徴とする [1] に記載の光導波路樹脂用組成物。

【化4】

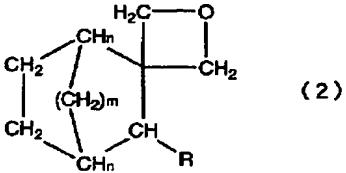


(式中 *R* は水素原子、または炭素数 1 ~ 12 のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、*m* は 0 ~ 2 の整数で、*n* は *m* が 0 の場合は 2、それ以外は 1 である。)

[3] 一般式 (1) で示される化合物が 2-オキサスピロ [3. 5] ノナー-6-エンまたは 5-メチル-2-オキサスピロ [3. 5] ノナー-6-エンであることを特徴とする [2] に記載の光導波路樹脂用組成物。

【0015】 [4] 分子内に少なくとも一個のオキセタニル基を有する脂環式化合物 (a) が一般式 (2) で表される化合物であることを特徴とする [1] に記載の光導波路樹脂用組成物。

【化5】



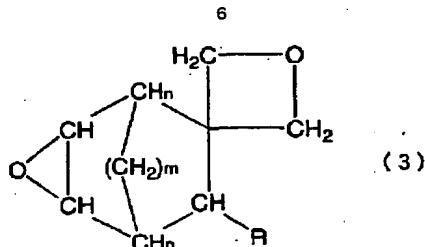
(式中 *R* は水素原子、または炭素数 1 ~ 12 のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、*m* は 0 ~ 2 の整数で、*n* は *m* が 0 の場合は 2、それ以外は 1 である。)

[5] 一般式 (2) で示される化合物が 2-オキサスピロ [3. 5] ノナンまたは 5-メチル-2-オキサスピロ [3. 5] ノナンであることを特徴とする [4] に記載の光導波路樹脂用組成物。

【0016】 [6] 分子内に少なくとも一個のオキセタニル基を有する脂環式化合物 (a) が一般式 (3) で表される化合物であることを特徴とする [1] に記載の光導波路樹脂用組成物。

【化6】

6



(式中 *R* は水素原子、または炭素数 1 ~ 12 のアルキル基、アリール基、アラルキル基、ハロゲン化アルキル基の各基であり、*m* は 0 ~ 2 の整数で、*n* は *m* が 0 の場合は 2、それ以外は 1 である。)

【0017】 [7] 一般式 (3) で示される化合物が 7, 8-エポキシ-5-メチル-2-オキサスピロ

[3. 5] ノナン、6, 7-エポキシ-2-オキサスピロ [3. 5] ノナンであることを特徴とする [6] に記載の光導波路樹脂用組成物。

[8] 分子内に少なくとも一個のオキセタニル基を有する脂環式化合物 (a) が一般式 (1)、一般式 (2) および一般式 (3) で表される化合物から選択された少なくとも一種であることを特徴とする [1] に記載の光導波路樹脂用組成物。

[9] 一個以上のエポキシ基を有し、オキセタニル基を有しない化合物 (b) を含有することを特徴とする

[1] ~ [8] のいずれか一つに記載の光導波路樹脂用組成物。

【0018】 [10] 一個以上のエポキシ基を有し、オキセタニル基を有しない化合物 (b) がフッ素原子を有することを特徴とする [9] に記載の光導波路樹脂用組成物。

[11] 活性エネルギー線の照射および／または加熱によりカチオン重合を開始させる化合物 (c) を含むことを特徴とする [1] ~ [10] のいずれか一つに記載の光導波路樹脂用組成物。

[12] 活性エネルギー線の照射および／または加熱によりカチオン重合を開始させる化合物 (c) がスルホニウム塩、ヨードニウム塩、ホスホニウム塩およびジアゾニウム塩の中から選ばれた 1 種以上である [11] に記載の光導波路樹脂用組成物。

【0019】 [13] ラジカル重合性化合物 (d) を含むことを特徴とする [1] ~ [12] のいずれか一つに記載の光導波路樹脂用組成物。

[14] 光ラジカル開始剤 (e) を含むことを特徴とする [1] ~ [13] のいずれか一つに記載の光導波路樹脂用組成物。

[15] 硬化物の 25°C におけるナトリウムの D 線に対する屈折率が、1.40 以上 1.70 以下の範囲内の値であることを特徴とする請求項 1 ~ 14 のいずれか一つに記載の光導波路樹脂用組成物。

【0020】 [16] [1] ~ [15] のいずれか一つに記載の光導波路樹脂用組成物を硬化させて得られた

光導波路。

【17】コア部およびクラッド部を有すると共に、コア部またはクラッド部の少なくとも一方が【1】～【15】のいずれか一つに記載の光導波路樹脂用組成物を硬化して得られたものであることを特徴とする光導波路。

【0021】【18】分子内に少なくとも一個のオキセタニル基を有する脂環式化合物(a)と活性エネルギー一線の照射および/または加熱によりカチオン重合を開始させる化合物(c)を含む光導波路樹脂用組成物を用いた層に活性エネルギー線を選択的に照射することにより、当該組成物を選択的に硬化させ、未硬化部分を除去する現像処理により光導波路を形成する光導波路の製造方法。

【19】【16】に記載の光導波路が使用された光デバイス。

【0022】

【発明の実施の形態】以下、本発明の実施の形態について詳細に説明する。

【0023】本発明の同一分子内に少なくとも一個のオキセタニル基を有する脂環式化合物

(a)（以後、化合物(a)と略す。）としては一般式(1)、一般式(2)または一般式(3)で表される脂環式化合物が好ましい。一般式(1)、(2)、(3)において、Rは各式それぞれ独立に、水素原子、炭素数1～12の直鎖状または分岐状の、アルキル基、アリール基、アラルキル基、ハログン化アルキル基の各基である。これらの中では水素原子、直鎖のアルキル基が好ましく、水素原子、メチル基が特に好ましい。mは0～2の整数で、nはmが0の場合は2、それ以外は1である。m=0とはメチレン鎖による橋かけが存在しないことを意味する。

【0024】炭素数1～12の直鎖状または分岐状の、アルキル基、アリール基、アラルキル基としてはメチル基、エチル基、イソプロピル基、フェニル基、ベンジル基等が挙げられる。

【0025】ハログン化アルキル基としてはフルオロアルキル基、クロロアルキル基、ブロモアルキル基等が挙げられる。これら各アルキル基は直鎖状または分岐状であり、各ハログン原子の数は1以上であればよい。

【0026】一般式(1)で表される化合物としては、2-オキサスピロ[3.5]ノナ-6-エン、9-メチル-2-オキサスピロ[3.5]ノナ-6-エン、2-オキサ-9-フェニルスピロ[3.5]ノナ-6-エン、9-トリフルオロメチル-2-オキサスピロ[3.5]ノナ-6-エン、スピロ[ビシクロ[2.2.1]ヘプタン-2,3'-オキセタン]、スピロ[ビシクロ[2.2.2]オクタン-2,3'-オキセタン]、スピロ[7-オキサビシクロ[2.2.1]ヘプタン-2,3'-オキセタン]、スピロ[3-メチルビシクロ[2.2.1]ヘプタン-2,3'-オキセタン]等が挙げられる。これらの中では2-オキサスピロ[3.5]ノナン、5-メチル-2-オキサスピロ[3.5]ノナンが好ましい。

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好ましい。

【0027】これらの化合物はオキセタニル基と炭素炭素二重結合を有しており、カチオン重合性のみでなく、ラジカル重合性にも優れ、硬化速度の向上に寄与している。また、脂環構造を有するため本発明の組成物の硬化物は耐熱性にも優れる。さらに、一般式(1)で示される化合物の多くは常温で液体であるため、本発明の組成物の粘度を下げることが可能となり、塗工性を向上させ得る。

【0028】一般式(2)で表される化合物としては、2-オキサスピロ[3.5]ノナン、7-メチル-2-オキサスピロ[3.5]ノナン、5-メチル-2-オキサスピロ[3.5]ノナン、2-オキサー-5-フェニルスピロ[3.5]ノナン、5-トリフルオロメチル-2-オキサスピロ[3.5]ノナン、スピロ[アダマンタン-2,3'-オキセタン]、スピロ[ビシクロ[2.2.1]ヘプタン-2,3'-オキセタン]、スピロ[ビシクロ[2.2.2]オクタン-2,3'-オキセタン]等が挙げられる。これらの中では2-オキサスピロ[3.5]ノナン、5-メチル-2-オキサスピロ[3.5]ノナンが好ましい。

【0029】これらの化合物はカチオン重合性に優れ組成物の硬化速度向上の効果を有する。またその脂環構造により本発明の組成物の硬化物に耐熱性を付与する。さらに、一般式(2)で示される化合物の多くは常温で液体であるため、本発明の組成物の粘度を下げることが可能となり、塗工性を向上させ得る。

【0030】一般式(3)で表される化合物としては、7,8-エポキシー-5-メチル-2-オキサスピロ[3.5]ノナン、7,8-エポキシー-5-エチル-2-オキサスピロ[3.5]ノナン、7,8-エポキシー-2-オキサー-5-フェニルスピロ[3.5]ノナン、7,8-エポキシー-5-トリフルオロメチル-2-オキサスピロ[3.5]ノナン、6,7-エポキシー-2-オキサスピロ[3.5]ノナン、スピロ[5,6-エポキシノルボルナン-2,3'-オキセタン]、スピロ[5,6-エポキシー-3-メチルノルボルナン-2,3'-オキセタン]等である。これらの中では7,8-エポキシー-5-メチル-2-オキサスピロ[3.5]ノナン、6,7-エポキシー-2-オキサスピロ[3.5]ノナンが好ましい。

【0031】これらの化合物はオキセタニル基とエポキシ基を併有しており、カチオン重合性にすぐれ、組成物の硬化速度の向上に寄与している。また、脂環構造を有しており、硬化物の耐熱性を高める。

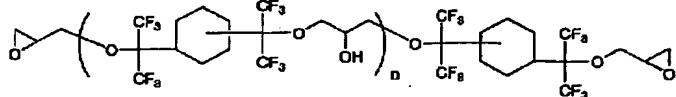
【0032】一般式(1)、(2)、(3)で表される分子内に一個以上のオキセタニル基を有する脂環式化合

物をはじめとする化合物(a)は、単独で、または2種以上の混合物として使用できる。これら化合物(a)の配合量(2種以上を併用する場合はそれらの合計量)は本発明の光導波路樹脂用組成物中、好ましくは1~90質量%、更に好ましくは10~60質量%である。

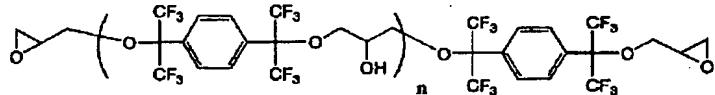
【0033】本発明の分子内に一個以上のエポキシ基を有し、オキセタニル基を有しない化合物(b)としては公知慣用のエポキシ化合物が使用できる。このエポキシ化合物は1分子中に一個以上のエポキシ基を有し、オキセタニル基を有しないものであれば特に限定されない。

【0034】具体的には、ビスフェノールAジグリシルエーテル、ビスフェノールFジグリシジルエーテル、ビスフェノールSジグリシジルエーテル、臭素化ビスフェノールAジグリシジルエーテル、臭素化ビスフェノールFジグリシジルエーテル、臭素化ビスフェノールSジグリシジルエーテル、ノボラック型エポキシ樹脂(例えばフェノール・ノボラック型エポキシ樹脂、クレゾール・ノボラック型エポキシ樹脂、臭素化フェノール・ノボラック型エポキシ樹脂)、水添ビスフェノールAジグリシジルエーテル、水添ビスフェノールFジグリシジルエーテル、水添ビスフェノールSジグリシジルエーテル、トリグリシジルイソシアヌレート等を用いることができる。

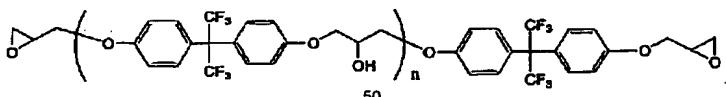
【0035】また、脂肪族エポキシ化合物として、(3,4-エポキシシクロヘキシル)メチル-3',4'-エポキシシクロヘキシカルボキシレート、2-(3,4-エポキシシクロヘキシル-5,5-スピロー3,4-エポキシ)シクロヘキサンメタージオキサン、ビス(3,4-エポキシシクロヘキシルメチル)アジペート、ビニルシクロヘキセンオキサイド、4-ビニルエポキシシクロヘキサン、ビス(3,4-エポキシ-6-メチルシクロヘキシルメチル)アジペート、3,4-エポキシ-6-メチルシクロヘキシル-3',4'-エポキシ-6' -メチルシクロヘキサンカルボキシレート、メチレンビス(3,4-エポキシシクロヘキサン)、ジシクロペンタジエンエポキサイド、リモネンジエポキサイド、エチレングリコールのジ(3,4-エ



【化8】



【化9】



ポキシシクロヘキシルメチル)エーテル、エチレンビス(3,4-エポキシシクロヘキサンカルボキシレート)が挙げられる。

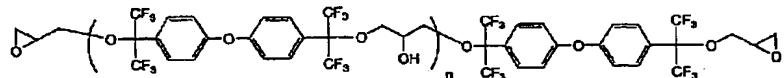
【0036】更にエポキシヘキサヒドロフタル酸ジオクチル、エポキシヘキサヒドロフタル酸ジ-2-エチルヘキシル、1,4-ブタンジオールジグリシジルエーテル、1,6-ヘキサンジオールジグリシジルエーテル、グリセリントリグリシジルエーテル、トリメチロールプロパントリグリシジルエーテル、ポリエチレングリコールジグリシジルエーテル、ポリプロピレングリコールジグリシジルエーテル、エチレングリコール、プロピレングリコール、グリセリン等の脂肪族多価アルコールに1種または2種以上のアルキレンオキサイドを付加することにより得られるポリエーテルポリオールのポリグリシジルエーテル類；脂肪族長鎖二塩基酸のジグリシジルエーテル類；脂肪族高級アルコールのモノグリシジルエーテル類；ブチルグリシジルエーテル、フェニルグリシジルエーテル、クレゾルグリシジルエーテル、ノニルフェニルグリシジルエーテル、グリシジルメタクリレート；フェノール、クレゾール、ブチルフェノールまたはこれらにアルキレンオキサイドを付加して得られるポリエーテルアルコールのモノグリシジルエーテル類；高級脂肪酸のグリシジルエステル類；エポキシ化大豆油；エポキシステアリン酸ブチル、エポキシステアリン酸オクチル、エポキシ化アマニ油、エポキシ化ポリブタジエン等を挙げることができる。

【0037】さらに本発明の光導波路の屈折率を調整するためにフッ素原子を有するフッ素化エポキシ化合物を使用することができる。フッ素化エポキシ化合物は、同様な構造を有する炭化水素型エポキシ化合物と比較して小さな屈折率を有し、光導波路用樹脂組成物に混合することにより所望の屈折率に調整することが可能である。

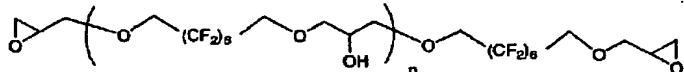
【0038】具体的には「応用物理第68巻第1号(1999)、p.4~13」に下記化合物の例が記載されているが、本発明はこれらに限定されるものではない。

【化7】

【化10】



【化11】



【0039】これら分子内に一個以上のエポキシ基を有し、オキセタニル基を有しない化合物（b）は単独でまたは2種以上混合して使用することができる。

【0040】化合物（b）の配合量（2種以上を併用する場合はそれらの合計量）は本発明における化合物

（a）の合計：100質量部に対して1～10,000質量部が好ましく、10～1,000質量部が特に好ましい。

【0041】本発明でいう活性エネルギー線の照射および/または加熱によりカチオン重合を開始させる化合物（c）は、加熱や紫外線などの活性エネルギー線の照射によって変化し、酸などのカチオン重合を開始させる物質を生成する化合物とすることができる。従って、化合物（c）は一種のカチオン重合開始剤であり、当業界では「酸発生剤」とも呼ばれている。以降、本発明では化合物（c）を酸発生型カチオン重合開始剤とも称する。

【0042】酸発生型カチオン重合開始剤は、加熱または紫外線などの光照射によって本発明の化合物（a）、化合物（b）およびその他のカチオン重合性物質（オキセタニル基を含む化合物など）のカチオン重合を促進し、本発明の光導波路樹脂用組成物の硬化を円滑に進行させる。

【0043】また、本発明でいう酸発生型カチオン重合開始剤は加熱や紫外線などの活性エネルギー線の照射によって変化し、酸などのカチオン重合を開始させる物質を生成する化合物であり、カルボン酸のように最初から酸の形をとっている化合物は含まれない。

【0044】酸発生型カチオン重合開始剤としては公知のスルホニウム塩、ヨードニウム塩、ホスホニウム塩、ジアゾニウム塩、アンモニウム塩およびフェロセン類等が挙げられる。以下に具体的に例示するが、これらの化合物に限定されるものではない。

【0045】スルホニウム塩系の酸発生型カチオン重合開始剤としては、ビス[4-(ジフェニルスルホニオ)フェニル]スルフィドビスヘキサフルオロホスフェート、ビス[4-(ジフェニルスルホニオ)フェニル]スルフィドビスヘキサフルオロアンチモネート、ビス[4-(ジフェニルスルホニオ)フェニル]スルフィドビステトラフルオロボレート、ビス[4-(ジフェニルスルホニオ)フェニル]スルフィドテトラキス(ペントフルオロフェニル)ボレート、ジフェニル-4-(

10 エニルチオ)フェニルスルホニウムヘキサフルオロホスフェート、ジフェニル-4-(フェニルチオ)フェニルスルホニウムヘキサフルオロアンチモネート、ジフェニル-4-(フェニルチオ)フェニルスルホニウムテトラフルオロボレート、ジフェニル-4-(フェニルチオ)フェニルスルホニウムテトラキス(ペントフルオロフェニル)ボレート、トリフェニルスルホニウムヘキサフルオロホスフェート、トリフェニルスルホニウムヘキサフルオロアンチモネート、トリフェニルスルホニウムテトラフルオロボレート、トリフェニルスルホニウムテトラキス(ペントフルオロフェニル)ボレート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]ビスヘキサフルオロホスフェート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]ビスヘキサフルオロアンチモネート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]ビスヘキサフルオロアンチモネート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]スルフィドビステトラフルオロボレート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]スルフィドビスヘキサフルオロアンチモネート、ビス[4-(ジ(4-(2-ヒドロキシエトキシ)フェニル)スルフィド]スルフィドテトラキス(ペントフルオロフェニル)ボレート、などが挙げられる。

【0046】ヨードニウム塩系の酸発生型カチオン重合開始剤としては、ジフェニルヨードニウムヘキサフルオロホスフェート、ジフェニルヨードニウムヘキサフルオロアンチモネート、ジフェニルヨードニウムテトラフルオロボレート、ジフェニルヨードニウムテトラキス(ペントフルオロフェニル)ボレート、ビス(デシルフェニル)ヨードニウムヘキサフルオロホスフェート、ビス(デシルフェニル)ヨードニウムヘキサフルオロアンチモネート、ビス(デシルフェニル)ヨードニウムテトラフルオロボレート、ビス(デシルフェニル)ヨードニウムテトラキス(ペントフルオロフェニル)ボレート、4-メチルフェニル-4-(1-メチルエチル)フェニルヨードニウムヘキサフルオロホスフェート、4-メチルフェニル-4-(1-メチルエチル)フェニルヨードニウムヘキサフルオロアンチモネート、4-メチルフェニル-4-(1-メチルエチル)フェニルヨードニウムテトラフルオロボレート、4-メチルフェニル-4-(1-メチルエチル)フェニルヨードニウムテトラキス(ペントフルオロフェニル)

ボレート、などが挙げられる。

【0047】ホスホニウム塩系の酸発生型カチオン重合開始剤としては、エチルトリフェニルホスホニウムテトラフルオロボレート、エチルトリフェニルホスホニウムヘキサフルオロホスフェート、エチルトリフェニルホスホニウムヘキサフルオロアンチモネート、テトラブチルホスホニウムテトラフルオロボレート、テトラブチルホスホニウムヘキサフルオロホスフェート、テトラブチルホスホニウムヘキサフルオロアンチモネートなどが挙げられる。

【0048】ジアゾニウム塩系の酸発生型カチオン重合開始剤としては、フェニルジアゾニウム ヘキサフルオロホスフェート、フェニルジアゾニウム ヘキサフルオロアンチモネート、フェニルジアゾニウム テトラフルオロボレート、フェニルジアゾニウム テトラキス(ペンタフルオロフェニル)ボレート、などが挙げられる。

【0049】アンモニウム塩系の酸発生型カチオン重合開始剤としては、1-ベンジル-2-シアノピリジニウム ヘキサフルオロホスフェート、1-ベンジル-2-シアノピリジニウム ヘキサフルオロアンチモネート、1-ベンジル-2-シアノピリジニウム ヘキサフルオロボレート、1-ベンジル-2-シアノピリジニウムテトラキス(ペンタフルオロフェニル)ボレート、1-(ナフチルメチル)-2-シアノピリジニウム ヘキサフルオロホスフェート、1-(ナフチルメチル)-2-シアノピリジニウム ヘキサフルオロアンチモネート、1-(ナフチルメチル)-2-シアノピリジニウム ヘキサフルオロボレート、1-(ナフチルメチル)-2-シアノピリジニウム テトラキス(ペンタフルオロフェニル)ボレート、などが挙げられる。

【0050】フェロセン系の酸発生型カチオン重合開始剤としては、(2, 4-シクロペンタジエン-1-イル) [(1-メチルエチル)ベンゼン] -Fe (II) ヘキサフルオロホスフェート、(2, 4-シクロペンタジエン-1-イル) [(1-メチルエチル)ベンゼン] -Fe (II) ヘキサフルオロアンチモネート、2, 4-シクロペンタジエン-1-イル) [(1-メチルエチル)ベンゼン] -Fe (II) テトラフルオロボレート、2, 4-シクロペンタジエン-1-イル) [(1-メチルエチル)ベンゼン] -Fe (II) テトラキス(ペンタフルオロフェニル)ボレート、などが挙げられる。

【0051】これらの酸発生型カチオン重合開始剤ではスルホニウム塩とヨードニウム塩系の開始剤が硬化速度、安定性、経済性の面から好ましい。市販品としては、旭電化工業社製SP-150、SP-170、CP-66、CP-77；ユニオンカーバイド社製CYRA CURE-UVI-6990、UVI-6974；日本曹達社製CI-2855、CI-2639；三新化学工業社製サンエイドSI-60；「イルガキュア261」(チバ・スペシャルティ・ケミカルズ社製(2, 4-シ

クロペンタジエン-1-イル) [(1-メチルエチル)ベンゼン] -Fe (II) ヘキサフルオロホスフェート、「ロードシリ(RHODORSIL) 2074」；(ローヌ・ブラン社製4-メチルフェニル-4-(1-メチルエチル)フェニルヨードニウム テトラキス(ペンタフルオロフェニル)ボレート)、などが挙げられる。

【0052】これら酸発生型カチオン重合開始剤は、上述した材料の中から選択し、単独で使用することもでき、2種類以上を組み合わせて使用することもできる。酸発生型カチオン重合開始剤の使用量の好適な範囲は、特に制限がないが、化合物(a)、化合物(b)の合計の配合量(後述の他のカチオン重合可能な化合物を併用する場合はそれらをあわせた合計量)100質量部に対して0.05~25質量部、好ましくは1~20質量部である。添加量が0.05質量部より少ないと感度不良となり充分に硬化するためには著しく大きな光照射エネルギーや長時間の高温処理が必要である。また、25質量部を超えて添加しても感度の向上はせず、経済的にも好ましくない。逆に組成物中に未硬化成分として残存する量が多くなり硬化物の物性が低下する恐れがある。

【0053】本発明においては以下に示すカチオン重合性モノマーも硬化性、硬化物物性に影響を与えない範囲で本発明の光導波路樹脂用組成物に添加することができる。このカチオン重合性モノマーは酸発生型カチオン重合開始剤の発生した酸により重合開始反応や架橋反応を起こす化合物であって化合物(a)、化合物(b)以外である化合物に分類される。例えばトリメチレンオキシド、3, 3-ジメチルオキセタン、3, 3-ジクロルメチルオキセタン、3-エチル-3-フェノキシメチルオキセタン、3-エチル-3-ヒドロキシメチルオキセタン(東亞合成社製；商品名EOXA)、ビス[(3-エチル-3-オキセタニルメトキシ)メチル]ベンゼン(別名キシリレンジオキセタン；東亞合成社製；商品名XDO)、トリ[(3-エチル-3-オキセタニルメトキシ)メチル]ベンゼン、ビス[(3-エチル-3-オキセタニルメトキシ)メチルフェニル]エーテル、3-エチル-3-[(オキシラニルメトキシ)メチル]オキセタン、(3-エチル-3-オキセタニルメトキシ)オリゴジメチルシロキサン等の脂環式化合物以外にオキセタニル基が付いているオキセタン化合物；テトラヒドロフラン、2, 3-ジメチルテトラヒドロフラン等のオキソラン化合物；トリオキサン、1, 3-ジオキソラン、1, 3, 6-トリオキサンシクロオクタン等の環状アセタール化合物； β -プロピオラクトン、 ϵ -カブロラクトン等の環状ラクトン化合物；エチレンスルフィド、1, 2-プロピレンスルフィド、チオエピクロロヒドリン等のチイラン化合物；3, 3-ジメチルチエタン等のチエタン化合物；エチレングリコールジビニルエーテル、トリエチレングリコルジビニルエーテル、トリメチ

ロールプロパントリビニルエーテル等のビニルエーテル化合物；エポキシ化合物とラクトンとの反応生成物であるスピロオルソエステル化合物；ビニルシクロヘキサン、イソブチレン、ポリブタジエン等のエチレン性不飽和化合物；環状エーテル化合物；環状チオエーテル化合物；ビニル化合物等を挙げることができる。

【0054】これらのカチオン重合性モノマーは1種を単独で添加することもできるし、あるいは2種以上を組み合わせて添加することもできる。これらカチオン重合性モノマーの配合量（2種以上を併用する場合はそれらの合計量）は本発明の化合物（a）の合計：100質量部に対して1～10,000質量部、好ましくは10～1,000質量部である。上記カチオン重合性モノマーのうち、分子内にカチオン重合性基を一つしか有さない化合物を化合物（a）の合計：100質量部に対し200質量部以上添加すると硬化性が低下し、硬化に必要なエネルギーが増大するため好ましくない。

【0055】本発明の光導波路樹脂用組成物に、光（活性エネルギー線）硬化性向上させるために本発明の目的を阻害しない範囲で、ラジカル重合性化合物（d）を添加することも可能である。化合物（d）としては、特に限定はないが、（メタ）アクリル酸エステル系の公知慣用のラジカル重合性モノマーが使用できる。具体的には、メチル（メタ）アクリレート、エチル（メタ）アクリレート、n-ブロピル（メタ）アクリレート、n-ブチル（メタ）アクリレート、2-エチルヘキシル（メタ）アクリレート、ラウリル（メタ）アクリレート、シクロヘキシル（メタ）アクリレート、フェノキシエチル（メタ）アクリレート、2-エトキシエチル（メタ）アクリレート、グリシジル（メタ）アクリレート、2-ヒドロキシエチル（メタ）アクリレート、ベンジル（メタ）アクリレート、エチレングリコールモノ（メタ）アクリレート等の单官能（メタ）アクリレート化合物；エチレングリコールジ（メタ）アクリレート、ポリエチレングリコールジ（メタ）アクリレート、トリメチロールプロパントリ（メタ）アクリレート、ペンタエリスリトールテトラ（メタ）アクリレート、ジペンタエリスリトールペンタ（メタ）アクリレート、多官能エポキシ（メタ）アクリレート樹脂、多官能ウレタン（メタ）アクリレート樹脂等を挙げることができる。

【0056】また本発明の光導波路の屈折率を調整する目的で、フッ素原子を有する（メタ）アクリレートモノマーを化合物（d）として使用することも可能である。具体的には2,2,2-トリフルオロエチル（メタ）アクリレート、2,2,3,3-テトラフルオロプロピル（メタ）アクリレート、ペンタフルオロプロピル（メタ）アクリレート、ヘキサフルオロイソブロピル（メタ）アクリレート、オクタフルオロペンチル（メタ）アクリレート等を挙げることができる。

【0057】化合物（d）の添加量は、本発明の化合物

（a）、化合物（b）、化合物（c）、およびそれら以外の上述のカチオン重合性化合物の総和100質量部に対して5～200質量部、好ましくは10～100質量部である。添加量が200質量部を超えると指触乾燥性が悪くなる。また、硬化において（メタ）アクリル基の架橋の割合が多くなるため、得られた硬化物の耐熱性、耐薬品性が低下する。

【0058】上記ラジカル重合性化合物（d）のラジカル重合を円滑に促進させるためには光ラジカル開始剤（e）を加えることが望ましく、光に感応しラジカルを発生する公知慣用のものが使用できる。ここで「光」とは、可視光線、紫外線、遠紫外線、X線、電子線等の放射線を意味する。光ラジカル開始剤（e）としては、例えばベンゾイン、ベンゾインエチルエーテル、ベンゾインイソブロピルエーテル、ベンゾイン-n-ブチルエーテル、ベンゾインイソブチルエーテル、アセトフェノン、ジメチルアミノアセトフェノン、2,2-ジメトキシ-2-フェニルアセトフェノン、2,2-ジエトキシ-2-メチル-1-フェニルプロパン-1-オノン、1-ヒドロキシシクロヘキシルフェニルケトン、2-メチル-1-[4-(メチルチオ)フェニル]-2-モルホリノプロパン-1-オノン（チバスペシャリティーケミカルズ社製；イルガキュア907）、4-(2-ヒドロキシエトキシ)フェニル-2-(ヒドロキシ-2-ブロピル)ケトン、ベンゾフェノン、p-フェニルベンゾフェノン、4,4'-ジエチルアミノベンゾフェノン、ジクロロベンゾフェノン、2-メチルアントラキノン、2-t-ブチルアントラキノン、2-アミノアントラキノン、2-メチルチオキサントン、2-エチルチオキサントン、2-クロロチオキサントン、2,4-ジエチルチオキサントン、ベンジルジメチルケタール、p-ジメチルアミン安息香酸エステル、2,4,6-トリメチルベンゾイルジフェニルfosfinオキサイド（BASF社製；ルシリントPO）、ビス(2,6-ジメトキシベンゾイル)-2,4,4-トリメチル-1-ペンチルfosfinオキサイド含有開始剤（チバスペシャリティーケミカルズ社製；イルガキュア1700,149,1800）、ビス(2,4,6-トリメチルベンゾイル)-1-フェニルfosfinオキサイド（チバスペシャリティーケミカルズ社製；イルガキュア819）等が挙げられる。これらを1種または2種以上の混合物として使用できる。

【0059】光ラジカル開始剤（e）の使用量は、組成物中のラジカル重合性化合物（d）の（メタ）アクリル基などのラジカル重合性官能基1当量に対し0.007～0.5モルを使用することができる。

【0060】本発明の光導波路樹脂用組成物には、必要に応じてイオントラップ剤を含ませることができる。イオントラップ剤は陰イオンや陽イオンから成る不純物と反応し、無害化する物質へと変化させることができる。

【0061】本発明の光導波路樹脂用組成物は更に脂肪族ポリオールを含んでよい。かかる脂肪族ポリオールは本発明の光導波路樹脂に可とう性を付与したり、硬化反応後の室温熟成において反応の完結性を高める等の効果を与えるものである。脂肪族ポリオールとしては、例えばエチレングリコール、プロピレングリコール、ポリエチレングリコール、ポリプロピレングリコール、ブチレングリコール等の(ポリ)アルキレングリコールの他、グリセリン、ポリグリセリン、ペンタエリスリトール、ポリカプロラクトンポリオール等が挙げられる。その配合量は、本発明の光導波路樹脂用組成物中の成分(a)～(e)およびその他のカチオン重合性モノマー成分の総和100質量部当たり、5～50質量部、好ましくは10～30質量部程度であってよい。

【0062】本発明の光導波路樹脂用組成物を活性エネルギー線のひとつである紫外線で重合硬化させる際は、重合速度を向上させるために、増感剤を使用することもできる。そのような目的で使用する増感剤としては、ピレン、ペリレン、2,4-ジエチルチオキサントン、2,4-ジメチルチオキサントン、2,4-ジクロロチオキサントン、フェノチアジンなどが挙げられる。増感剤を併用する場合の使用量は、光酸発生型カチオン重合開始剤100質量部に対して、0.1～100質量部の範囲が好ましい。

【0063】さらに必要に応じて、シリコーン系、フッ素系、高分子系等の消泡剤；レベリング剤；イミダゾール系、チアゾール系、トリアゾール系、シランカップリング剤等の密着性付与剤、例えば信越シリコーン社製のシランカップリング剤、KBM303, KBM403, KBM402；三酸化アンチモン、リン酸エステル、赤リン及びメラミン樹脂をはじめとする含窒素化合物等の難燃剤、シリコーンオイルやシリコーンゴム粉末等の応力緩和剤のような公知慣用の添加剤類を用いることができる。

【0064】本発明の光導波路樹脂用組成物はこれまでに記述してきた化合物(a)、化合物(b)、化合物(c)などの構成物質を羽根による攪拌機、攪拌混練機、ペイントシェーカー、ニーダー、三本ロールミル等の公知慣用の混合装置で混合することができる。混合装置は各構成物質を均一に混合することができる装置であれば特に限定はないが、組成物の粘度などを考慮して選定する必要がある。

【0065】本発明における光導波路樹脂用組成物は活性エネルギー線の照射および／または加熱によって重合(硬化)させることができる。ここでいう活性エネルギー線とは、紫外線、X線、電子線、γ線等を示す。紫外線を照射する場合の光源としてはメタルハライドランプ、水銀アークランプ、キセノンアークランプ、蛍光ランプ、炭素アークランプ、タンクステンハロゲン複写ランプ、および太陽光等を挙げられる。

【0066】本発明の光導波路樹脂用組成物を加熱により硬化させる場合、加熱条件は、好ましくは約50～250℃、より好ましくは約75～200℃において約0.2～60分、好ましくは約0.5～20分、より好ましくは約1～10分の条件としてよい。

【0067】本発明の光導波路の屈折率は25℃におけるナトリウムのD線に対して1.40～1.70であることが望ましく、この範囲で光導波路のコア部またはクラッド部を形成する。そのため、光導波路樹脂用組成物の屈折率も1.40～1.70であることが望ましい。光導波路を構成するコア部とクラッド部は屈折率が1.5程度で、コア部とクラッド部との屈折率差が、シングルモードの場合には0.001程度以上、マルチモードの場合には0.01～0.1程度以上であれば、光伝搬特性に優れた光導波路を形成することができる。

【0068】一般的に光導波路樹脂用組成物はこれまで記述したようにオキセタン化合物、エポキシ化合物などの混合物である。これらオキセタン化合物、エポキシ化合物は屈折率が1.40～1.70程度であり、これらの化合物を適切に選択することや配合比を変化させることによって任意に光導波路樹脂の屈折率を制御することが可能である。

【0069】次に、光導波路樹脂用組成物を用いた光導波路の製造方法の一例について、図1を参照して説明する。

【0070】まず、図1(A)に示したように、シリコーンよりも基板10上に、光導波路クラッド部用組成物を硬化後の厚さが30μm程度となるように塗布してクラッド部用組成物層11aを形成する。

【0071】次に、図1(B)に示したように、クラッド部用組成物層11aに対して、超高压水銀ランプを用い、25mW/cm²の出力で60秒間紫外線を全面に照射することにより、光導波路クラッド部用組成物を硬化させる。これにより、図1(C)に示したように、光導波路のクラッド部11が形成される。なお、組成物層11aを完全に硬化させると、屈折率は、例えば0.025程度大きくなる。クラッド部を硬化する場合、光硬化による方法も可能であるが、全面硬化の場合には熱カチオン硬化剤を用いた熱硬化も可能である。

【0072】次に、図1(D)に示したように、クラッド部11上に、光導波路コア部用組成物を硬化後の厚さが30μm程度となるように塗布して組成物層12aを形成する。

【0073】さらに、ストライプ状の開口部を有するフォトマスク21を介して組成物層12aに対して紫外線を照射する。具体的には、フォトマスク21をコア部用組成物層12a上にコア部用組成物層12aと接触しないように位置合わせして配置し、フォトマスク21側から組成物層12aに向けて紫外線を照射する。紫外線の照射は、超高压水銀ランプを用いて20～200mW/

cm^2 の出力で5~120秒間行う。これにより、図1(E)に示したように、コア部用組成物層12aのフォトマスク21の開口に対応する部分12a1では、光導波路コア部用組成物が硬化する。

【0074】ここで、未硬化のコア部用組成物層12aとフォトマスク21とが密着した状態で紫外線を照射すると、コア部用組成物層12aとフォトマスク21とが接着してしまうため、上述したようにフォトマスク21をコア部用組成物層12aと接触しないように配置する必要がある。このような方法としては、マスクと被露光体との間に $100\mu\text{m}$ 程度のギャップを設けて露光を行うプロキシティ露光法や、マスクと被露光体とを離間させて、光学的に結像させて露光を行う投影露光法などがある。

【0075】紫外線を照射してから所定の時間が経過したのち、フォトマスク21により紫外線が照射されず、未硬化状態の部分12a2をアセトンなどの現像液により溶解除去する。このとき、クラッド部11およびコア部組成物層12aの硬化した部分12a1の架橋密度が高くなっているので、これらの領域が溶解する可能性は少ない。

【0076】次に、リンス液としてイソプロピルアルコールを用いて硬化物層12aを洗浄し、硬化物層12aの内部に浸透して硬化物層12aを膨潤させているアセトンを除去する。これにより、図1(F)に示したように、例えば平面形状が帯状であり、屈折率が1.56程度の複数の光導波路のコア部12が形成される。

【0077】最後に、図1(G)に示したように、クラッド部11の露出面およびコア部12上にクラッド部11と同一の材料を用いて、クラッド部11と同様の方法により、クラッド部13を形成し、コア部12とクラッド部11、13とからなる埋め込み型の光導波路を完成させる。

【0078】このようにして製造された光導波路では、一端面に光信号が入射すると、この光信号は内部を伝搬し、他端面から出射する。

【0079】本発明における光導波路の製造方法において用いられる現像液は、未硬化状態の部分に対する溶解性、すなわち光導波路樹脂用組成物に対する溶解性に優れ、硬化した部分に与える影響が少ない溶剤を用いることが好ましい。このような溶剤としては、酢酸エチル、酢酸ブチル、 γ -ブチロラクトン、エチレングリコールモノエチルエーテルアセテート、プロピレングリコールモノメチルエーテルアセテートなどのエステル；エチレングリコールモノエチルエーテル、ジエチレングリコールモノエチルエーテル、プロピレングリコールモノメチルエーテル、ジプロピレングリコールモノメチルエーテルなどのエーテルアルコール；アセトン、メチルエチルケトン、メチルイソブチルケトンなどのケトン；ジオキサン、テトラヒドロフランなどのエーテル；ベンゼン、

トルエン、キシレンなどの芳香族炭化水素などが挙げられる。これらは1種で用いてもかまわないし、2種以上を混合して用いても構わない。また、これら溶剤に光導波路樹脂用組成物の溶解性が低い溶媒、例えば、水やアルコールなどを添加して硬化物の膨潤性を調整してもよい。これら溶剤の内、アセトンは、毒性が低く、沸点も低いので、全般的に取り扱いやすいという利点も有しており好ましい。

【0080】本発明における光導波路の製造方法において用いられるリンス液としてイソプロピルアルコールを用いるのは、硬化したコア部がほとんど侵されず、現像液と相溶しやすいので、未硬化部分を完全に除去することができると共に、硬化したコア部分をほぼ完全な形で残して基板上面にゴミを残すことなく仕上げができるからである。

【0081】このような目的で使用されるリンス液としては、現像液の種類によっても異なるが、メタノール、エタノール、イソプロピルアルコール、ブタノールなどの低級アルコールが好ましい。さらに、好ましくはイソプロピルアルコールである。

【0082】

【実施例】以下、実施例をあげて本発明をさらに詳細に説明するが、本発明はこれら実施例になんら限定されるものではない。なお、実施例および比較例の中の「部」は特に断りの無い限り質量部である。

【0083】なお、実施例および比較例で使用した材料のうち、市販品は次の通りであり、精製することなく、そのまま使用した。

P O X：東亞合成社製、3-エチル-3-フェノキシメチルオキセタン

X D O：東亞合成社製、1,4-ビス[(3-エチル-3-オキセタニルメトキシ)メチル]ベンゼン

3 0 0 0：ダイセル化学工業社製（商品名セロキサイド3000）、リモネンジオキサイド

2 1 1 0：旭電化工業製（商品名KRM-2110）、2官能脂環式エポキシ樹脂

8 2 8：油化シェルエポキシ社製（商品名エピコート828）、ビスフェノールA型エポキシ樹脂

M-3 0 9：東亞合成社製、トリメチロールプロパントリニアクリレート

3 0 0 0 A：共栄社化学社製エポキシエステル3000A、ビスフェノールAジグリシジルエーテルアクリル酸付加物

S I - 6 0 L：三新化学工業社製（商品名サンエイドS I - 6 0 L）、熱カチオン重合開始剤（スルホニウム塩）

6 9 9 0：ユニオンカーバイド社製（商品名UVI-6990）、光カチオン重合開始剤

9 0 7：チバ・スペシャルティ・ケミカルズ社製（商品名イルガキュア907）、光重合開始剤

【0084】市販されていない化合物は発明者が化学合成したものを使用した。即ち、7, 8-エポキシー-5-メチル-2-オキサスピロ[3.5]ノナンおよび6, 7-エポキシー-2-オキサスピロ[3.5]ノナンについては米国特許3388105号記載の方法を参考に本発明者が合成した。詳しくは、7, 8-エポキシー-5-メチル-2-オキサスピロ[3.5]ノナンは下記の通りに合成した。

【0085】<6-メチル-3-シクロヘキセン-1, 1-ジメタノールの合成>3つロフラスコにブタジエンとクロトンアルデヒドとのDiels-Alder反応生成物である2-メチル-4-シクロヘキセン-1-カルボアルデヒド327g、メタノール600ml及び37%のホルマリン水729gを投入し、この溶液を攪拌しながら60℃に昇温させた。続いてKOH 252gを蒸留水600mlに溶解した溶液を2時間かけて滴下した。7時間攪拌し続けた後、反応溶液を減圧濃縮し、二層の残渣を得た。約150mlに濃縮された油層を300mlの蒸留水で洗浄した。油層を減圧濃縮した後、3,5-ジ(t-ブチル)-4-ヒドロキシトルエン(BHT)を50mg添加し、減圧蒸留を行い、無色結晶である6-メチル-3-シクロヘキセン-1, 1-ジメタノール311g(収率82%)を得た。

【0086】<6-メチル-3-シクロヘキセン-1, 1-ジメタノール環状炭酸エステルの合成>3つロフラスコに6-メチル-3-シクロヘキセン-1, 1-ジメタノール310g(1.99mol)、ジメチルカルボネート(DMC)894g及び炭酸カリウム0.93gを仕込み、90℃に昇温し4時間還流させた。反応溶液を室温に戻し、炭酸カリウムを濾別した。BHTを120mg添加した後、残存するDMC及びメタノールを2kPa(15mmHg)の減圧下で除去し、続いて減圧蒸留を行い常温無色結晶である6-メチル-3-シクロヘキセン-1, 1-ジメタノール環状炭酸エステルを326g(収率89.4%)を得た。

【0087】<9-メチル-2-オキサスピロ[3.5]ノナ-6-エン(CHEO)の合成>3つロフラスコに6-メチル-3-シクロヘキセン-1, 1-ジメタノール環状炭酸エステル321.15g、BHT 642mg(0.2質量%)、LiCl 1.93gを仕込み、マントルヒーターを用いて275℃で加熱攪拌した。生成物を直ちに約8kPa(60mmHg)の減圧下、系外に抜き出し、留出なくなるまで4時間加熱を続けた。生成物にBHT 600mgを加え、減圧蒸留を行い無色透明液体であるCHEOを187g(収率71%)を得た。

【0088】<7, 8-エポキシー-5-メチル-2-オキサスピロ[3.5]ノナン(ECHO)の合成>CHEO 50gを150mlのジクロロメタンに溶解させてから反応器に投入した。m-クロロ過安息香酸93.7gを400mlのジクロロメタンに懸濁させたものを反

応溶液が40℃を超えないように1時間かけて滴下した。析出したm-クロロ安息香酸を濾別し、冷ジクロロメタンでよく洗浄した。有機層に水酸化カルシウム15.0gを投入し、30分攪拌後、析出した結晶を濾別し、冷ジクロロメタンで洗浄した。有機層を5%のNaHSO4水、飽和食塩水で洗浄した後濃縮し、減圧蒸留により常温で無色半固体形状のECHOを38.1g(収率73.7%)を得た。

【0089】<7, 8-エポキシー-5-エチル-2-オキサスピロ[3.5]ノナン(ECHO)の合成>ECHOの合成で用いたブタジエンとクロトンアルデヒドとのDiels-Alder反応生成物の代わりに、ブタジエンとtrans-2-ベンテナールとのDiels-Alder反応生成物である6-エチル-3-シクロヘキセン-1-カルボアルデヒドを使用し、上記と類似の手順により本発明者が合成した。

【0090】<7, 8-エポキシー-5-トリフルオロメチル-2-オキサスピロ[3.5]ノナン(EFCHO)の合成>ECHOの合成で用いたブタジエンとクロトンアルデヒドとのDiels-Alder反応生成物の代わりに、ブタジエンとtrans-4, 4, 4-トリフルオロ-2-ブテナールとのDiels-Alder反応生成物を使用し、上記と類似の手順により本発明者が合成した。

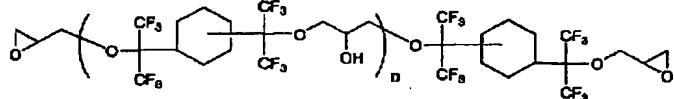
【0091】<5-メチル-2-オキサスピロ[3.5]ノナン(CHO)の合成>1L 3つロフラスコに前記の6-メチル-3-シクロヘキセン-1, 1-ジメタノールをトルエン中で5%パラジウム/活性炭を触媒として水素ガスによって水添して得た2-メチルシクロヘキサン-1, 1-ジメタノール474g、炭酸ジメチル405g、炭酸カリウム1.4gを入れ、オイルバス中100℃の温度で加熱攪拌し、生成するメタノールを常圧で系外に留去しつつ反応を14時間行った。最終的に反応容器内を10mmHgまで減圧にし、相当する炭酸エステルを収率95%で得た。

【0092】得られた環状炭酸エステルをそのまま250℃で加熱攪拌し、生じた炭酸ガスを冷却装置の上部より系外へ排出しつつ反応を10時間行った。この反応溶液を蒸留精製し、CHO 230gを得た。

【0093】<2-オキサ-5-フェニルスピロ[3.5]ノナン(PCCHO)の合成>CHOの合成で用いた2-メチルシクロヘキサン-1, 1-ジメタノールの代わりに、ブタジエンとtrans-ケイ皮アルデヒドとのDiels-Alder反応生成物をトルエン中で5%パラジウム/活性炭を触媒として水素ガスによって水添して得られる2-フェニルシクロヘキサン-1, 1-ジメタノールを使用し、上記と同様の手順により本発明者が合成した。

【0094】<スピロ[ビシクロ[2.2.1]ヘプタ-2, 3'-オキセタン](NRBO)の合成>CHO合成時に用いたブタジエンとクロトンアルデヒドのDi

els-Alder反応物から得られた6-メチル-3-シクロヘキセン-1, 1-ジメタノールの代わりに、シクロペンタジエンとアクロレインの反応生成物であるビシクロ[2.2.1]ヘプター-5-エン-1, 1-ジメタノールをトルエン中で5%パラジウム/活性炭を触媒として水素ガスによって水添したビシクロ[2.2.1]ヘプタン-1, 1-ジメタノールを用いて全く同様の反応を行なうことにより上記と同様の手順により本発明者が合成した。



Macromolecules 1996, 29, 2006-2010 に従い合成した。得られたフッ素化エポキシ樹脂Aは繰り返し単位のnが0のものが100%、シクロヘキサンの結合が1, 3であるもの85%、1, 4であるもの15%の混合物を用いた。

【0096】<実施例1～8、比較例1～3>まず、光導波路樹脂用組成物の光硬化性について検討した。表1に示す配合（表中の数値は質量部）でオキセタン化合物、エポキシ化合物、光カチオン重合開始剤などを混合して各光導波路樹脂用組成物を得た。

【0097】このようにして得られた各光導波路樹脂用組成物について、以下のようにして光硬化性試験を行った。ガラス基板上に組成物層の厚さを100μmとなるように塗布した。その後、メタルハライドランプを用いて24mW/cm²の出力で10秒間照射し、組成物層を硬化した。硬化した組成物層のタックの状態を指先で調べ、得られた結果を表1に示す。ここでは、硬化物層にタックがなかった場合は「○」、ややタックがある場合には「△」、タックが存在した場合は「×」と記した。

【0098】実施例1～8は本発明のオキセタニル基を有する脂環式化合物(a)とエポキシ化合物の混合物であるが、硬化性に優れていることがわかる。

【0099】一方、比較例1はエポキシ化合物のみの組成物であるが、全く硬化しておらず著しいタックを示し

行うことにより上記と同様の手順により本発明者が合成した。

【0095】<ビス(1,1,3,3-ヘキサフルオロイソプロピル)シクロヘキサンのジグリシジルエーテルの合成(フッ素化エポキシ樹脂A)>

【化12】

た。また、比較例2および3はオキセタン化合物として脂環式構造を有しないオキセタン化合物を用いた例である。エポキシ化合物のみの組成物に比べると硬化性の向上は確認されたが、本発明のオキセタニル基を有する脂環式化合物(a)を混合した実施例に比較すると硬化性はやや劣っていた。実施例4は本発明のオキセタン化合物にその他のオキセタン化合物の混合例であるが十分硬化していた。本発明のオキセタニル基を有する脂環式化合物(a)の硬化性が反映されている。また、実施例5ではラジカル重合性化合物とラジカル重合開始剤を混合した例であるがこの実施例も十分硬化していた。

【0100】このように本発明のオキセタニル基を有する脂環式化合物(a)を含む光導波路樹脂用組成物は硬化性に優れていることが分かる。

【0101】更に、得られた各光導波路樹脂用組成物の完全硬化後のもの(更に光を照射して完全に硬化させた)について、25℃におけるナトリウムのD線に対する屈折率を測定し、結果を表1に示した。屈折率はAbbe屈折率計(株式会社アタゴ製Abbe屈折率計1型)で測定した。屈折率は1.465から1.550と変化することができ、クラッド部用、コア部用の組成物として調整できることが分かった。

【0102】

【表1】

	化合物	実施例								比較例		
		1	2	3	4	5	6	7	8	1	2	3
オキセタン化合物(a)	CHO	20										
	CHEO	30										
	PCHO									10		
	NRBO					10						
	ECHO		50	50	40	30	25					
	EECHO						25					
	EFCHO							10				
その他のオキセタン化合物	POX										30	
	XDO				10				10			50
エポキシ化合物	セロキサイド3000									10		
	KRM-2110	50	40				30		30	80	40	
	エピコート828	30	30	50	40		20	50		10	30	50
	フッ素化エポキシ樹脂A					50			40			
ラジカル重合性化合物	M-309						5					
	3000A							15				
光カチオン重合開始剤	UVI-6990	3	3	3	3	3	3	3	3	3	3	3
光ラジカル開始剤	ルガキュア907						1					
光硬化性		○	○	○	○	○	○	○	○	×	△	△
硬化後の屈折率		1.532	1.531	1.547	1.505	1.465	1.498	1.550	1.480	1.523	1.571	1.569

【0103】<実施例9～11、比較例4～6>光導波路樹脂用組成物の熱硬化性について検討した。実施例1～8、比較例1～3の光カチオン重合開始剤を熱カチオン重合開始剤SI-60Lに変更した以外は同様にして各光導波路樹脂用組成物を調整した。配合量を(質量部)を表2に示す。

【0104】このようにして得られた各光導波路樹脂用組成物について、以下のようにして熱硬化性試験を行った。サンプルレビン中に各組成物を入れ、80℃のオイルバスに浸けた。1分間硬化した後の各組成物の性状について次のように熱硬化性を判定した。粘度がほとんど変化していないものは「×」、増粘しているものは

	化合物	実施例			比較例		
		9	10	11	4	5	6
オキセタン化合物(a)	CHO	20					
	CHEO		30				
	ECHO			50			
その他のオキセタン化合物	POX				30		
	XDO					50	
エポキシ化合物	セロキサイド3000				10		
	KRM-2110	50	40		60	40	
	エピコート828	30	30	50	10	30	50
熱カチオン重合開始剤	SI-60L	3	3	3	3	3	3
熱硬化性		○～△	○～△	○	×	△	△

【0108】<実施例12>光導波路の製造例

・クラッド部用組成物

ECHO 40質量部、2110 10質量部、828 10質量部、光カチオン重合開始剤UVI-6990

3質量部を十分均一になるように混合した。更に、フィルタリングを行ってダストなどを除去することにより、光導波路クラッド部用組成物を得た。なお、各材料は、実施例1～8で述べたものと同一の品名のものを用いた。

【0109】・コア部用組成物

ECHO 30質量部、2110 10質量部、828 60質量部、光カチオン重合開始剤UVI-6990

3質量部を十分均一になるように混合した。更に、フィルタリングを行ってダストなどを除去することにより、光導波路コア部用組成物を得た。なお、各材料は、実施例1～8で述べたものと同一の品名のものを用いた。

【0110】次に、光導波路の製造について説明する。図1(A)に示したように、シリコンよりなる基板100を用意し、この基板100上の全面に、スピンドル法により、光導波路クラッド部用組成物よりなる組成物層11aを形成した。その後、図1(B)に示したように、組成物層11aに対して超高压水銀ランプを用いて2500mJ/cm²の紫外線を照射した。組成物層11aを硬化することによりクラッド部11を形成した(図1(C))。このとき、クラッド部11の厚さは30μmであった。また、25℃におけるナトリウムのD線に対する屈折率を測定したところ1.558であり、クラッド部11との屈折率差が0.046であった。

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【0111】次に、図1(D)に示したように、クラッド部11上に、スピンドル法を用いて、光導波路コア部用組成物を塗布することにより組成物層12aを形成した。

【0112】さらに、幅が30μmのストライプ状の開口を有するフォトマスク21を基板100の表面から100μm離間するように配置し、このフォトマスク21を介して、超高压水銀ランプを用いて組成物層12aに対して1500mJ/cm²の紫外線を照射した(プロキシミティ露光法)。これにより、図1(E)に示したように、組成物層12aのフォトマスクの開口に対応する部分12a1では、組成物層12aを構成する光導波路コア部用組成物が硬化した。このとき、硬化した組成物層12aの厚さは30μmであった。また、25℃におけるナトリウムのD線に対する屈折率を測定したところ1.558であり、クラッド部11との屈折率差が0.046であった。

【0113】紫外線を照射したのち、フォトマスク21により紫外線が照射されず、未硬化状態の部分12a2を、アセトンにより溶解除去した。続いて、イソプロピルアルコールを用いて硬化物層12a(12a1)を洗净した。このようにして、図1(F)に示したように、平面形状が帯状である複数のコア部12を形成した。

【0114】最後に、図1(G)に示したように、クラッド部11の露出面およびコア部12の上に、クラッド部11と同じ組成物を用いて、クラッド部11と同様の方法によりクラッド部13を形成し、埋め込み型の光導波路を作製した。

【0115】<実施例13>幅が50μmのストライプ

状の開口を有するフォトマスク21(図1(D)参照)を用いて、幅 $50\mu\text{m}$ のコア部を形成したことを除き、実施例12と同様にして光導波路を作製した。

【0116】<実施例14>幅が $70\mu\text{m}$ のストライプ状の開口を有するフォトマスク21を用いて、幅 $70\mu\text{m}$ のコア部を形成したことを除き、実施例12と同様にして光導波路を作製した。

【0117】このようにして得られた実施例12～14の光導波路について、光伝搬損失に関する試験をそれぞれ行った。この試験は、波長 790nm および 650nm の半導体レーザを使用して、TE(Transverse Electrō)モードおよびTM(Transverse Magnetic)モードにおける伝搬損失を、カットバック法(光導波路を徐々に短くカットしながら、光導波路の出力パワーを測定す

る方法)により測定した。得られた結果を表3に示す。

【0118】なお、TEモードとは、光導波路の断面にのみ電界成分が存在し、光伝搬方向に磁界成分を有するモードである。また、TMモードとは、光導波路の断面にのみ磁界成分が存在し、光伝搬方向に電界成分を有するモードである。

【0119】表3からも分かるように、実施例12～14の光導波路は、TEモードおよびTMモードのいずれのモードにおいても、 $0.22\sim0.37\text{dB/cm}$ の小さい値が得られ、光伝搬損失の少ない良好なものであった。

【0120】

【表3】

測定波長 (nm)	伝搬モード	光伝搬損失(dB/cm)		
		実施例12	実施例13	実施例14
790	TEモード	0.26	0.25	0.23
	TMモード	0.25	0.23	0.22
650	TEモード	0.35	0.37	0.34
	TMモード	0.34	0.35	0.33

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【0121】

【発明の効果】本発明のオキセタニル基を有する脂環式化合物(a)を含有する光導波路樹脂用組成物は光カチオン硬化、熱カチオン硬化いずれの場合にも反応性が高く、迅速に硬化を進行させることができる。

【0122】また、本発明のオキセタニル基を有する脂環式化合物(a)は、エポキシ化合物やその他のオキセタン化合物と混合することにより屈折率を変化させることができあり、それぞれ屈折率の異なるコア部、クラッド部用の組成物を任意に造りうることが出来る。

路の作製過程の一例を示す図である。

【0124】

【符号の説明】

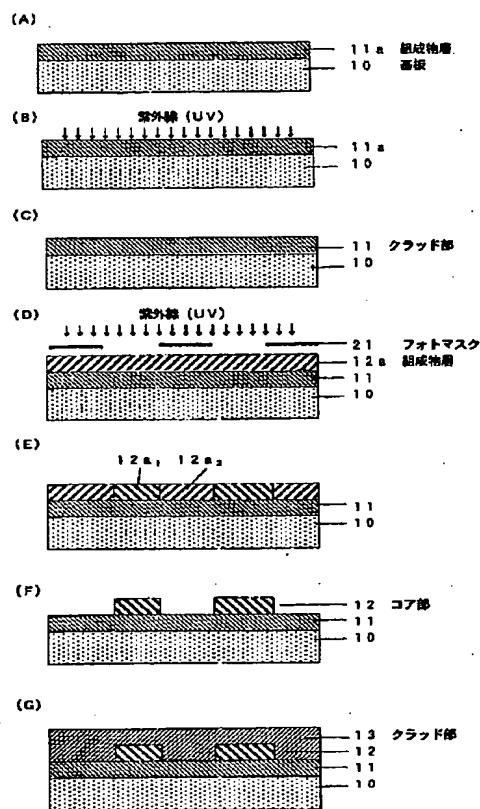
- 11a クラッド部用光導波路樹脂用組成物層
- 10 基板
- 11 クラッド部(クラッド用光導波路樹脂用組成物の硬化物)
- 21 フォトマスク
- 12a コア用部光導波路樹脂用組成物層
- 12a₁ コア部用光導波路樹脂用組成物の硬化物
- 12a₂ コア部用光導波路樹脂用組成物の未硬化物
- 12 コア部
- 13 クラッド部

【0123】

【図面の簡単な説明】

【図1】本発明の光導波路樹脂用組成物を用いた光導波

【図1】



フロントページの続き

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